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Rio Blanco Oil Shale Project

PROGRESS REPORT 4 - SUMMARY

Gulf Oil Corporation
and
Standard Oil Company (Indiana)
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PROGRESS REPORT 4 - SUMMARY

TRACT C-a OIL SHALE DEVELOPMENT

to

AREA OIL SHALE SUPERVISOR

UNITED STATES GEOLOGICAL SURVEY

October 31, 1975

by

RIO BLANCO OIL SHALE PROJECT

Gulf Oil Corporation
and
Standard Oil Company (Indiana)

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INTRODUCTION

Rio Blanco Oil Shale Project (Gulf Oil Corporation and Standard Oil Company of Indiana), hereafter referred to in this report as RBOSP, is presenting its fourth summary progress report for Tract C-a to the USGS Area Oil Shale Supervisor (AOSS). This report is a summary of work accomplished during the period June 1, 1975 through August 31, 1975. Data collected in the Geotechnical Data Gathering and the Environmental Baseline Data Gathering Projects for this period are on file in the AOSS office in Grand Junction, Colorado. These data comprise Progress Report 4. This summary report presents an overview and highlights of these data and has been correlated to and organized consistent with Progress Report 4.

It should be noted that results of data taken but not available in time for this progress report will be included in following progress report(s).

In response to requests by several members of the Oil Shale Environmental Advisory Panel, abstracts of the Geotechnical and Environmental Baseline sections are included in this report. They are located immediately behind the appropriate section divider sheets.

In keeping with the policy established in Progress Reports 2 and 3 - Summaries, an Appendix section is included with this summary report. It provides an update in the areas being studied for the DDP outside the scopes required for these quarterly reports.

Figure 1 is a location map of Tract C-a showing major drainages, roads, towns and counties in the vicinity of the tract. Figure 2 shows Tract C-a in greater detail and generally locates the drill holes, stream gaging stations, air quality towers and roads.

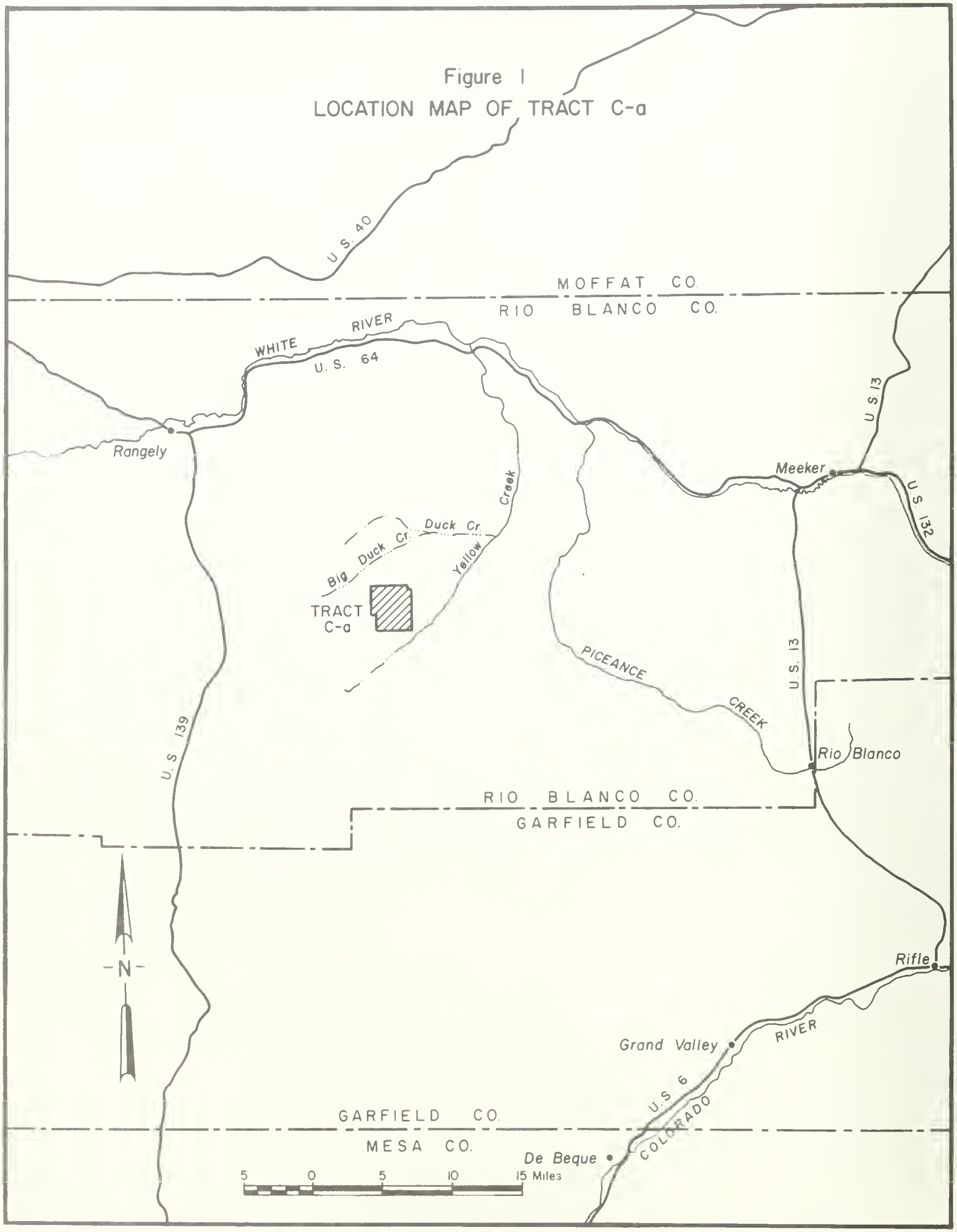


Figure 1

LOCATION MAP OF TRACT C-a

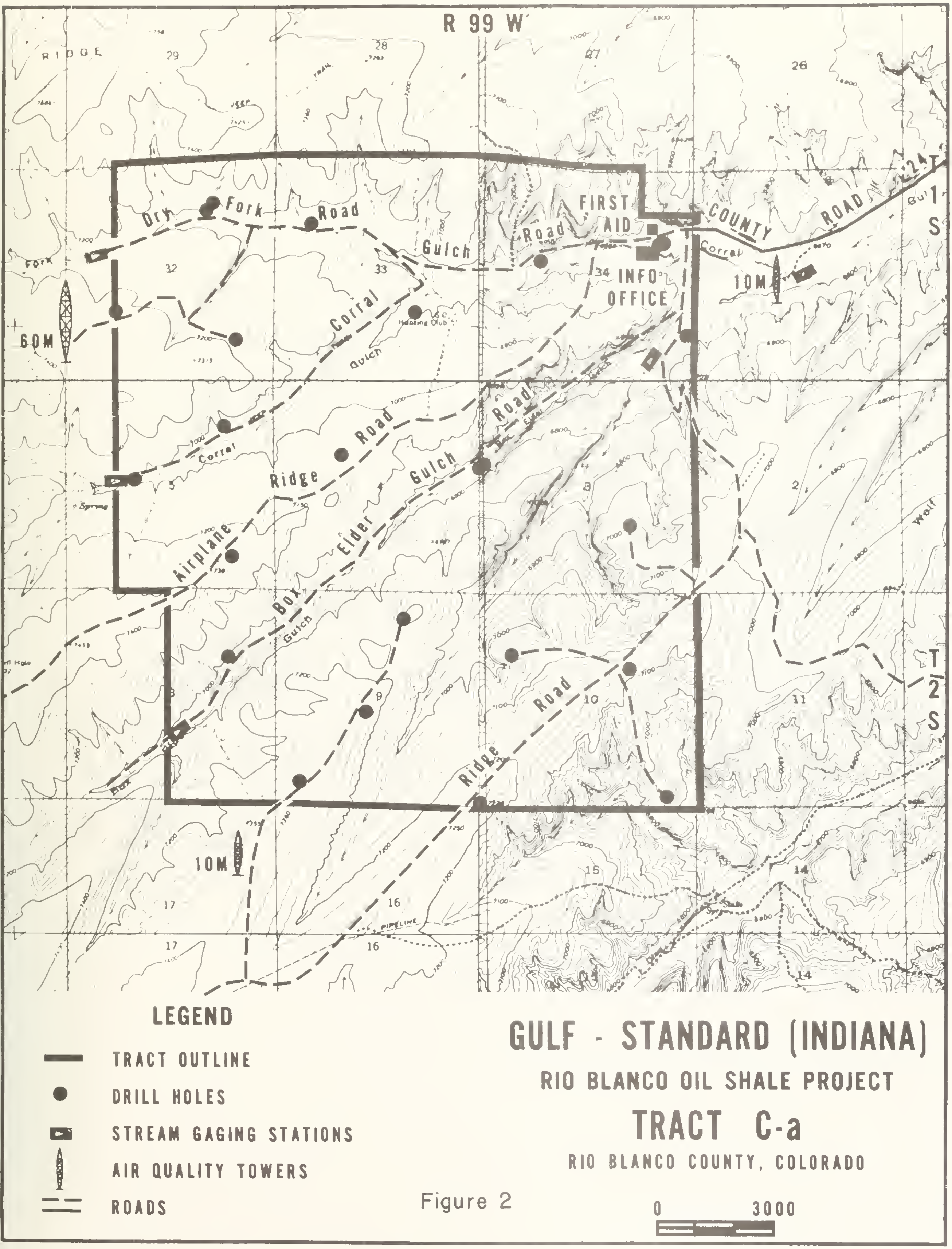

R 99 W
RIDGE
29
28
27
26
Dry Fork Road
Gulch Road
FIRST AID
INFO OFFICE
COUNTY ROAD 24
T 1 S
Corral
32
33
34
60M
10M
Corral Gulch
Corral
3
Ridge Road
Airplane
Box Elder Gulch Road
Box Gulch
2
8
9
10
11
Ridge Road
T 2 S
Wolf
15
14
16
17
PIPELINE
LEGEND
TRACT OUTLINE
DRILL HOLES
STREAM GAGING STATIONS
AIR QUALITY TOWERS
ROADS
GULF - STANDARD (INDIANA)
RIO BLANCO OIL SHALE PROJECT
TRACT C-a
RIO BLANCO COUNTY, COLORADO
0
3000

Figure 2

ABSTRACT

The Geotechnical Data Gathering Project is subdivided into the Geologic Program and the Hydrologic Program. The two programs are designed to provide data required for engineering studies as well as data to establish baseline conditions as stipulated in the oil shale lease.

The two programs were initiated in the Spring and Summer of 1974 with the commencement of a core drilling and hydrology monitoring program. This progress report updates the status of each of the programs for the period from June through August 1975.

Much of the activity relating to the Geologic Program during the quarterly reporting period concerned resource data refinement for input to various engineering studies. Confirmation oil shale assaying of some of the core intervals was completed during the reporting period. These assays indicated that some of the sample intervals of two coreholes would have to be reassayed as confirmation testing disclosed some discrepancies. The additional testing is currently being done.

During the quarterly reporting period, activity under the Hydrologic Program included: commencement of construction of four additional surface gaging stations; drilling of eight additional alluvial aquifer test holes; drilling of an additional deep aquifer monitoring hole; and the ongoing monitoring and sampling of the various streams and holes in the Tract C-a vicinity.

Four stream gaging stations reporting flow during the period are listed below with average dissolved solids in milligrams per liter (mg/l) for the portion of the reporting period for which data was available.

Stream Gaging Station	Dissolved Solids (mg/l)
Corral Gulch Near West Line Tract C-a	699
Corral Gulch East of Tract C-a.	742
Box Elder Gulch Near West Line Tract C-a	502
Yellow Creek Near White River	2484

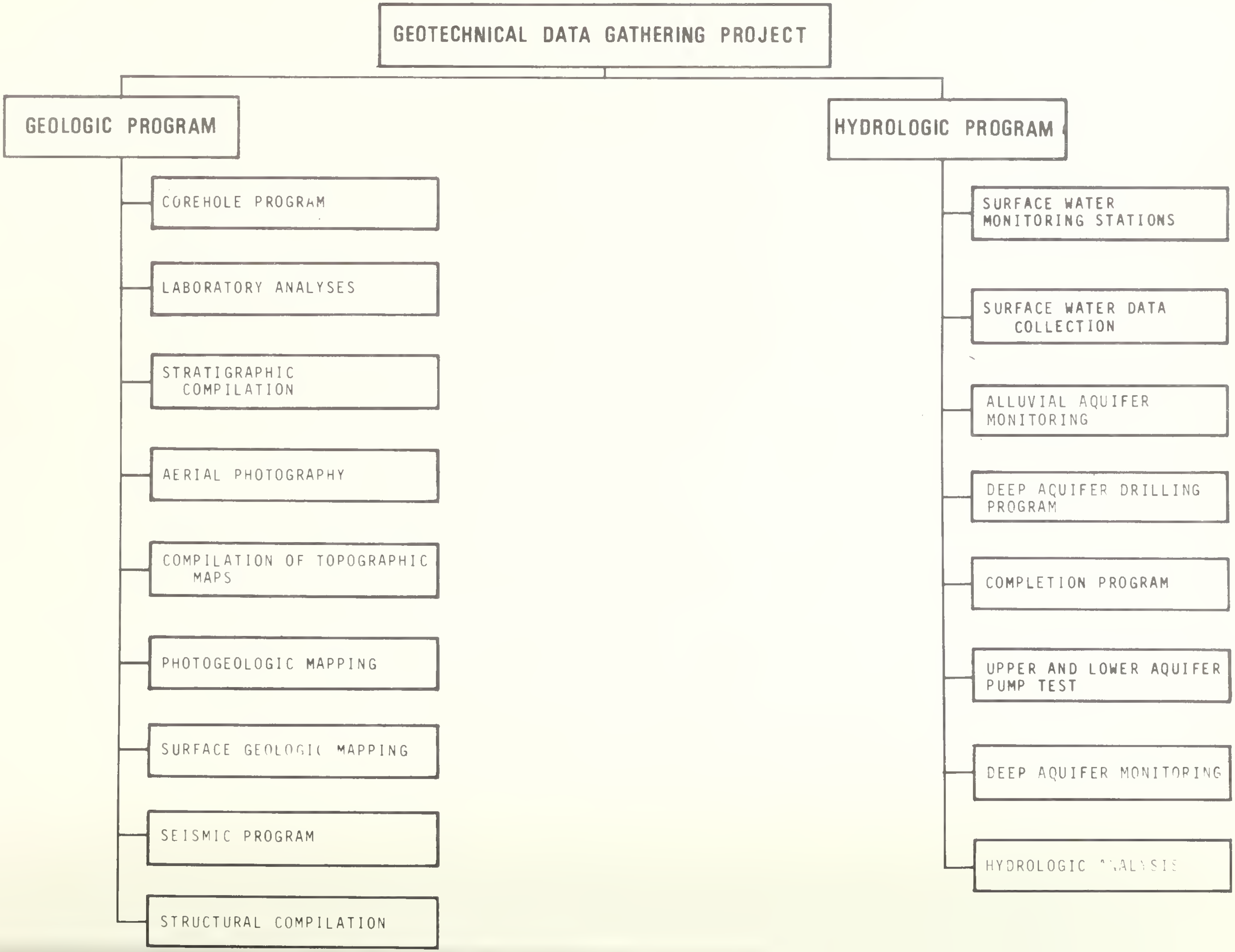
Precipitation from the three reporting storage type rain gages averaged about 1/2 inch per month for the months of June and July 1975 for which data is presently available.

The average water quality from samples of the upper aquifer and samples of the lower aquifer indicate the upper aquifer is of better quality, averaging about 1,200 mg/l dissolved solids in comparison with 1,600 mg/l dissolved solids for the lower aquifer. Review of analyses of samples from upper and lower aquifers shows the primary chemical constituents of the aquifer waters to be sodium and bicarbonate.

1.0 GEOTECHNICAL DATA GATHERING PROJECT

A significant portion of the Detailed Development Plan (DDP) is being formulated from the data gathered through the Geotechnical Data Gathering Project that was described in RBOSP Progress Report 2 - Summary. Figure 1.0-1 from that summary is included here and illustrates the project breakdown of the Geologic and the Hydrologic Programs. The Hydrologic Program has been altered by removing dewatering analysis from the scope of work of that program. Dewatering analysis was previously described in section 1.2.9 of preceding RBOSP's Progress Report 2 and 3 Summaries. The dewatering analysis is now included as part of the Engineering Studies and will be described in the DDP. Section 1.2.8, Data Input to Mathematical Model, has been redesignated Hydrologic Program-Summary and Analysis and will include interpretation of the hydrologic data from each of the tasks.

Figure 1.0 - 1


GEOTECHNICAL DATA GATHERING PROJECT
GEOLOGIC PROGRAM
COREHOLE PROGRAM
LABORATORY ANALYSES
STRATIGRAPHIC COMPILATION
AERIAL PHOTOGRAPHY
COMPILATION OF TOPOGRAPHIC MAPS
PHOTOGEOLOGIC MAPPING
SURFACE GEOLOGIC MAPPING
SEISMIC PROGRAM
STRUCTURAL COMPILATION
HYDROLOGIC PROGRAM
SURFACE WATER MONITORING STATIONS
SURFACE WATER DATA COLLECTION
ALLUVIAL AQUIFER MONITORING
DEEP AQUIFER DRILLING PROGRAM
COMPLETION PROGRAM
UPPER AND LOWER AQUIFER PUMP TEST
DEEP AQUIFER MONITORING
HYDROLOGIC ANALYSIS

1.1 Geologic Program

The portion of the DDP concerning mining and processing is based on resource parameters which are being defined under the Geologic Program. Figure 1.1-1, a functional flow diagram, is again presented as a review of the nine tasks making up the program. During the quarterly reporting period from June 1, 1975 to August 31, 1975 much of the activity concerning the Geologic Program was related to the refinement of resource data for input to the various engineering studies being conducted for the DDP. During the report quarter, confirmation oil shale assaying of some of the oil shale core intervals was completed. These assays indicated that some sample intervals of coreholes G-S 4-5 and G-S 6 would have to be reassayed as the confirmation testing has disclosed some discrepancies. This is currently being done. This additional testing is described in section 1.1.2.1 of RBOSP Progress Report 4 - Summary. Rock mechanics tests have been completed; however, the final report on the rock mechanics data is still being written and therefore is not included in this progress report. Activities under the other major tasks are essentially complete.

1.1.1 Corehole Program

A description of the corehole program was presented in RBOSP Progress Report 2 - Summary. Figure 1.1-2 is a map of Tract C-a showing the pre-lease coreholes as well as the location of Gulf-Standard (Indiana) coreholes drilled during the summer and fall of 1974. The drilling locations have been graded and fenced prior to seeding in the fall as requested by the Area Oil Shale Supervisor.

1.1.2 Laboratory Analyses

The oil shale core from the corehole program has provided the samples for a variety of laboratory analyses to provide data input to the engineering studies from which a major portion of the DDP will be conceived. Oil shale assays are the major data input to technical and economic engineering studies concerning the development of an oil shale resource. Nahcolite and extractable alumina analyses have also been performed to aid in projecting the potential for by-product recovery. Trace element analyses were performed to determine if any of seven particular trace elements (cadmium, antimony, arsenic, mercury, selenium, fluride ion, and boron) exist in fresh or spent oil shale in potentially harmful concentrations. Gas samples were taken and analyzed to determine if hazardous concentrations of flammable or poisonous gas could occur

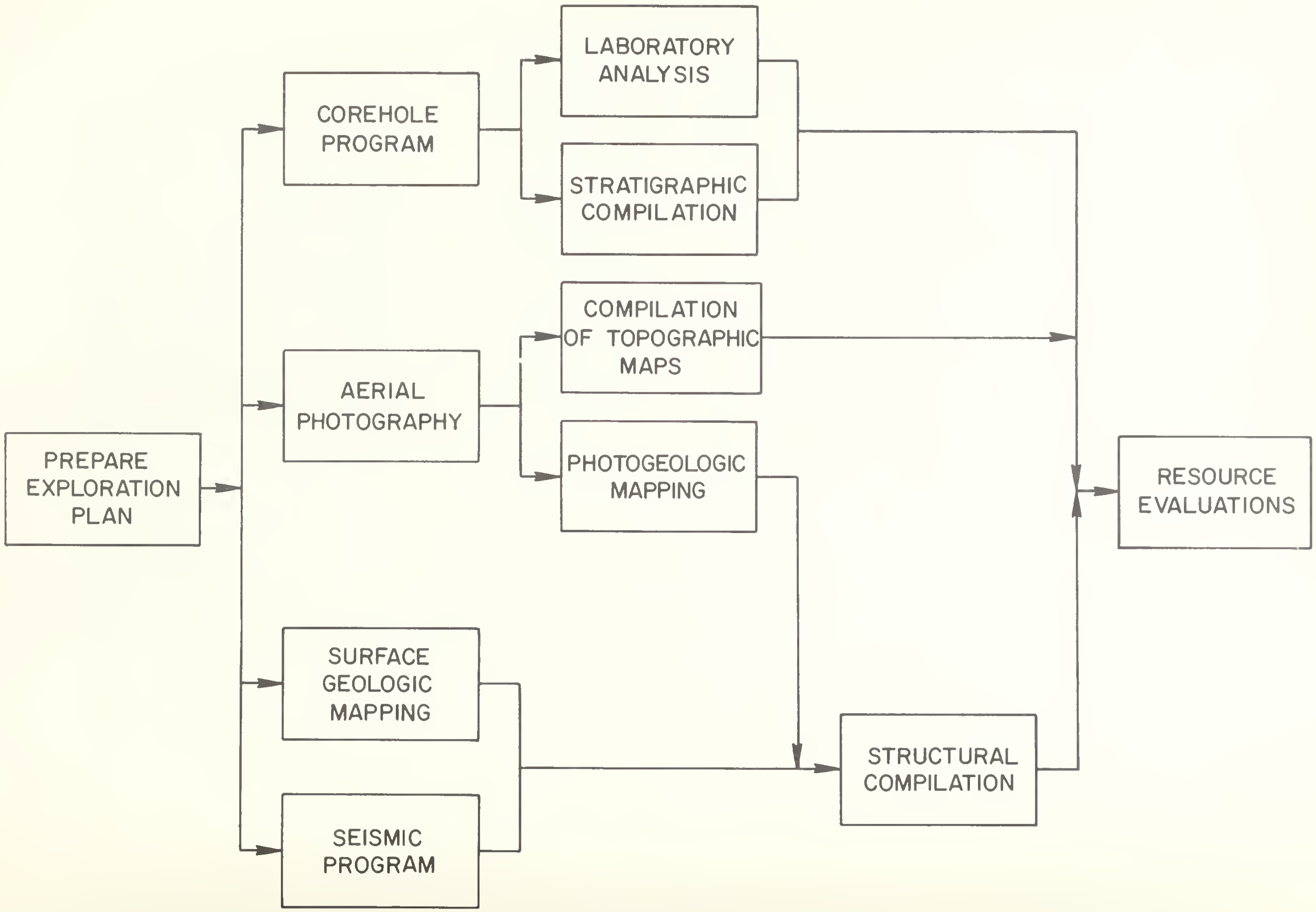
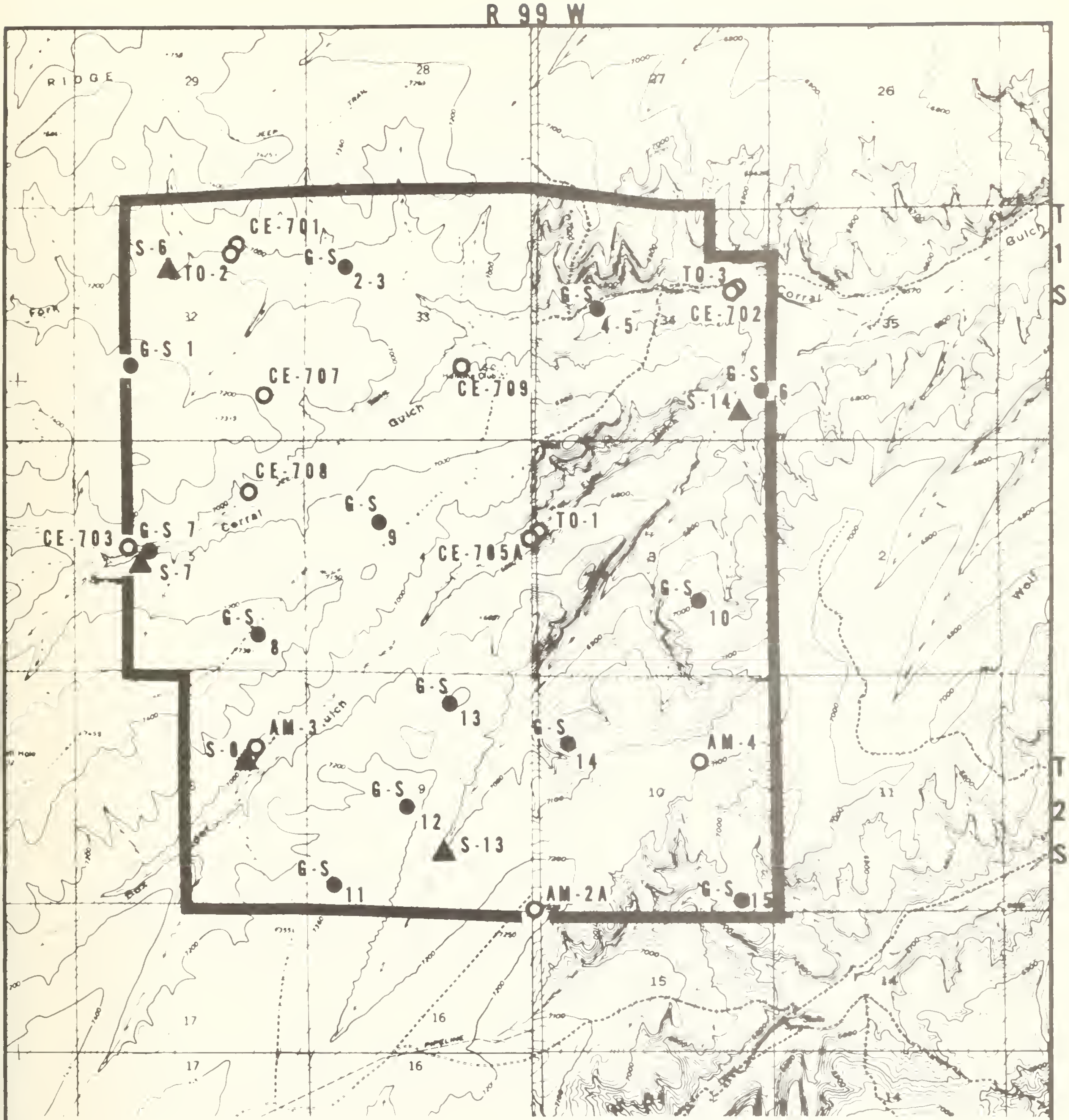


Figure 1.1-1

GEOLOGIC PROGRAM FUNCTIONAL FLOW DIAGRAM



GULF - STANDARD (INDIANA)

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

COREHOLE PROGRAM

PRE-SALE CORE HOLES

CE ○ CAMERON

TO ○ TOSCO

AM ○ AMOCO

POST SALE CORE HOLES

G-S ● GULF - STANDARD

S-6 ▲ ALLUVIAL AQUIFER TEST WELL

FIGURE 1.1-2

during mining. If such concentrations could occur then design of equipment and mine procedure must be permissible for underground gassy conditions. Rock mechanics tests were conducted to determine rock strength characteristics important to design of mine workings.

1.1.2.1 Oil Shale Assays

The entire core from G-S 13 has been withheld from assay as reported in RBOSP Progress Report 2 - Summary and RBOSP Progress Report 3 - Summary. The bulk of the other cores has been assayed and reported to the Area Oil Shale Supervisor. Correlations of assay data with respect to stratigraphy showed unexpected differences in assay results of the lower portions of two coreholes, G-S 4-5 and G-S 6. Subsequently a total of 45 confirmation assays were run on samples from these two coreholes. A significant disagreement between the results of the original assay of the core samples and the rerun assays of the same core samples was detected. As a result, core intervals in the lower portion of both holes G-S 4-5 and G-S 6 are being re-assayed. The results of the re-assay will be reported in the appropriate (timely) progress report.

1.1.2.2 Nahcolite Analyses

The results of the nahcolite analyses were reported to the Area Oil Shale Supervisor as described in section 1.1.2 of RBOSP Progress Report 2 - Summary.

1.1.2.3 Extractable Alumina

Extractable alumina in spent shale was described in section 1.1.2.3 of RBOSP Progress Report 2 - Summary. The concentration of extractable alumina in spent shale varies considerably with stratigraphy. Studies are continuing to determine the commercial potential of alumina extraction consistent with the development of Tract C-a oil shale.

1.1.2.4 Trace Element Analyses

The analyses of seven trace elements in fresh and spent oil shale samples were reported in section 1.1.2.4 of RBOSP Progress Report 2 - Summary. The mineral identification and occurrence of the same seven trace elements were reported in RBOSP Progress Report 3 - Summary.

1.1.2.5 Gas Samples

The gas sampling program is complete as reported in section 1.1.2.5 of RBOSP Progress Report 2 - Summary.

1.1.2.6 Rock Mechanics

The rock mechanics testing program was described in section 1.1.2.6 of RBOSP Progress Report 2 - Summary. Rock mechanics testing has been completed; however, the final report is still being prepared. It is anticipated that the rock mechanics data will be reported in RBOSP Progress Report 5.

1.1.3 Stratigraphic Compilation

The stratigraphic compilation has been completed as reported in section 1.1.3 of RBOSP Progress Report 2 - Summary and section 1.1.3 of RBOSP Progress Report 3 - Summary.

1.1.4 Aerial Photography

Arrangements have been made for aerial photography of an additional 8200 acres covering the 84 Mesa area north of Tract C-a. The photography will be used in the detailed topographic mapping of 84 Mesa.

1.1.5 Compilation of Topographic Maps

Revisions of the topographic mapping for Tract C-a were shipped under separate cover as a part of section 1.1.5 on RBOSP Progress Report 3. New topographic mapping of approximately 8200 acres in the 84 Mesa area will be compiled after black and white aerial photography has been completed.

1.1.6 Photogeologic Mapping

Photogeologic mapping was completed as reported in section 1.1.6 of RBOSP Progress Report 2 - Summary.

1.1.7 Surface Geologic Mapping

The surface geologic mapping of about ten square miles was completed as reported in section 1.1.7 of RBOSP Progress Report 2 - Summary.

1.1.8 Seismic Program

The seismic program was discontinued as reported in section 1.1.8 of RBOSP Progress Report 2.

1.1.9 Structural Compilation

A Middle A-groove structure map was compiled from photogeologic, surface geologic and subsurface corehole control. The map was submitted in section 1.1.9 of RBOSP Progress Report 2. Two additional faults have been observed in the northwest corner of Tract C-a. Several other fault interpretations were changed to a minor degree. A middle A-groove structure map is being revised accordingly and will be submitted as a part of the DDP.

1.2 Hydrologic Program

Rio Blanco Oil Shale Project implemented the surface and subsurface Hydrologic Program to establish baseline hydrologic conditions and to acquire data required for the design and planning of mine dewatering. The program was originally divided into nine tasks, but has been modified slightly in that the dewatering analysis described in section 1.2.9 of preceding progress reports has been removed from the Hydrologic Program scope of work and added to the Engineering Studies scope of work. The dewatering analysis will be presented as part of the DDP. Section 1.2.8, Data Input to Mathematical Modeling has been redesignated Hydrologic Summary and Analysis and Figure 1.2-1 is a revised functional flow diagram showing the logic of eight tasks.

Activity during the quarter included construction of four additional surface gaging stations, the drilling of eight additional shallow alluvial aquifer test holes and drilling of an additional deep aquifer monitoring hole. Each of the hydrologic tasks was reviewed and analyzed during the quarter. RBOSP Progress Report 4 includes hydrologic data generated during the quarter and is submitted in three parts: (1) Interpretive Text, (2) Interpretive Text Appendix, and (3) Raw Data. Data obtained during the corehole drilling project were presented in RBOSP Progress Report 2, while data obtained during the formal pumping test were presented in RBOSP Progress Report 3. RBOSP Progress Report 4 contains data obtained from the hydrologic monitoring program, the alluvial test hole drilling, the drilling of a deep monitor hole, and hydrlogic interpretive analyses. The interpretive data based on information collected to date in this report includes recharge and leakage analysis, permeability, apparent velocities, piezometric levels, transmissivity areal plots, and Jacob plot analysis. In addition, areal distribution of selected chemical constituents are also presented. A summary of the status and data of each of the hydrologic tasks follows.

1.2.1 Surface Water Monitoring Stations

To obtain the required surface water data required, RBOSP has contracted with the Colorado River Water Conservation District to have the Water Resources Division of the United States Geological Survey construct and operate the surface water monitoring stations. RBOSP Progress Reports 2 and 3 described the seven operating surface water gaging stations and six rain gaging stations. During the report quarter Water Resources Division of the USGS began construction on four additional stream gaging stations. The four new stations

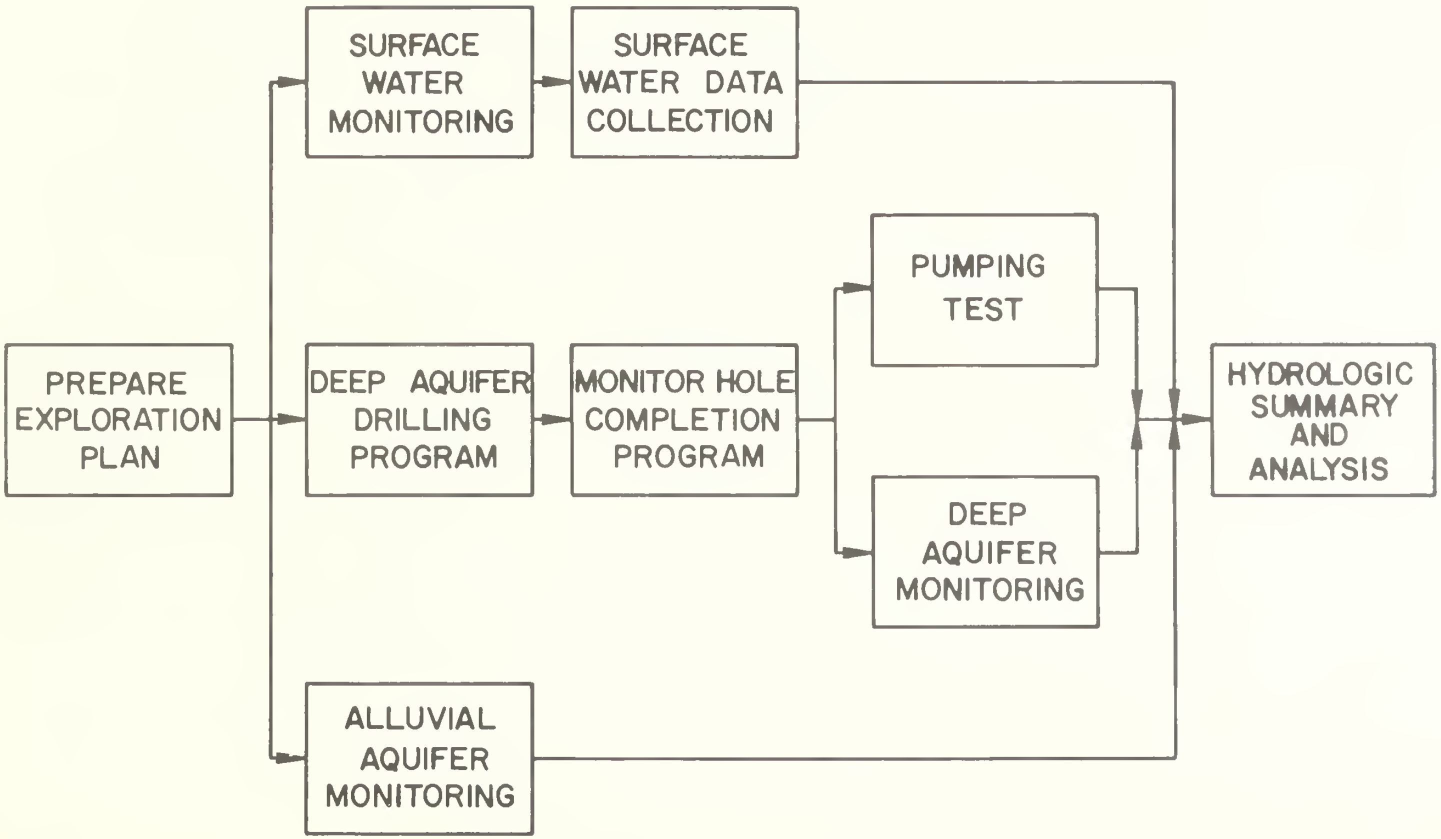

PREPARE EXPLORATION PLAN
SURFACE WATER MONITORING
SURFACE WATER DATA COLLECTION
DEEP AQUIFER DRILLING PROGRAM
MONITOR HOLE COMPLETION PROGRAM
PUMPING TEST
DEEP AQUIFER MONITORING
ALLUVIAL AQUIFER MONITORING
HYDROLOGIC SUMMARY AND ANALYSIS

Figure 1.2-1
HYDROLOGIC PROGRAM FUNCTIONAL FLOW DIAGRAM
RBOSP

are for data collection from 84 Mesa and surrounding area. Stream monitoring was initiated at the new stream gaging sites several months before the start of construction, August 1975. Table 1.2-1 lists each of the eleven stream gaging stations, the USGS identification number, and a description of the location of each station. The six rain gages are also listed on Table 1.2-1. Figure 1.2-2 is a map showing the location of the eleven stream gaging stations, the six rain gaging stations and fifteen alluvial aquifer monitor holes.

The data collection schedule for each of the eleven stream gaging stations and each of the six rain gages is shown on Table 1.2-2. To date continuous temperature and specific conductance data have not been received from the Water Resources Division of the USGS. The USGS also reports that the sediment discharge data will be submitted at the end of the water year (September 30, 1975).

1.2.2 Surface Water Data Collection

Surface hydrologic data obtained from the stream gaging stations are reduced by the Water Resources Division of the USGS and presented to RBOSP in computer printout form. RBOSP Progress Report 4 contains only the data from each station that were available at the time of writing, through the month of July. The surface water data collection program was described in detail in RBOSP Progress Reports 2 and 3.

Only four of the operating seven stream gaging stations recorded any discharge during the period beginning in May, 1975, and ending in August, 1975. The four gaging stations are: Corral Gulch near west line Tract C-a, Box Elder Gulch near the west line Tract C-a, Corral Gulch east of Tract C-a and Yellow Creek near the White River. Copies of USGS computer printouts of the water analyses are contained in the Raw Data submittal of RBOSP Progress Report 4. Tables 1.2-3, 1.2-4, 1.2-5, and 1.2-6 are summaries of the water analyses for the four stream gaging stations for which discharge was reported during the quarter. Review of the USGS instantaneous discharge, conductivity, boron and fluoride data from May through August was made for Corral Gulch east of Tract C-a, Corral Gulch near the west line of Tract C-a and the Yelow Creek stream gaging stations. Data from the stream gaging station on Box Elder Gulch near the west line of Tract C-a were not thought to represent a large enough time span to establish reliable trends in instantaneous discharge, conductivity, or concentrations of boron and fluorides. The data from the Box Elder Gulch stream gaging station is presented in section 1.2.2 of RBOSP Progress Report 4 - Interpretive Text.

TABLE 1.2-1
LOCATION AND USGS IDENTIFICATION NUMBERS FOR STREAM AND RAIN GAGING STATIONS
Tract C-a and Vicinity

USGS Identification number	Location
09306237	Dry Fork near west line Tract C-a
09306235	Corral Gulch near west line Tract C-a
09306240	Box Elder Gulch near west line Tract C-a
09306242	Corral Gulch east of Tract C-a
09306230†	Stake Springs Draw near confluence with Corral Gulch
09306255	Yellow Creek near White River, Colorado
09306241	"Rinky Dink" Gulch near east line Tract C-a
09306248	*Upper Big Duck Creek north of 84 Mesa
09306250	*Lower Big Duck Creek north of 84 Mesa
09306246	*Tributary to Yellow Creek east of 84 Mesa
09306244	*Corral Gulch near 84 Ranch
	Rain Storage-Type Gages
09306235	Corral Gulch near west line Tract C-a
09306237	Dry Fork near west line Tract C-a
09306240	Box Elder Gulch near west line Tract C-a
	Recording Rain Gage
09306230	Stake Springs Draw near confluence with Corral Gulch
09306255	Yellow Creek near White River, Colorado
No number	Cathedral Bluffs located in NW 1/4, NW 1/4, Sec. 14, T2S, R100W

† Reported as U.S.G.S. I.D. number 09306200 in RBOSP Progress Reports 2 and 3.

* Stream gaging stations presently under construction.

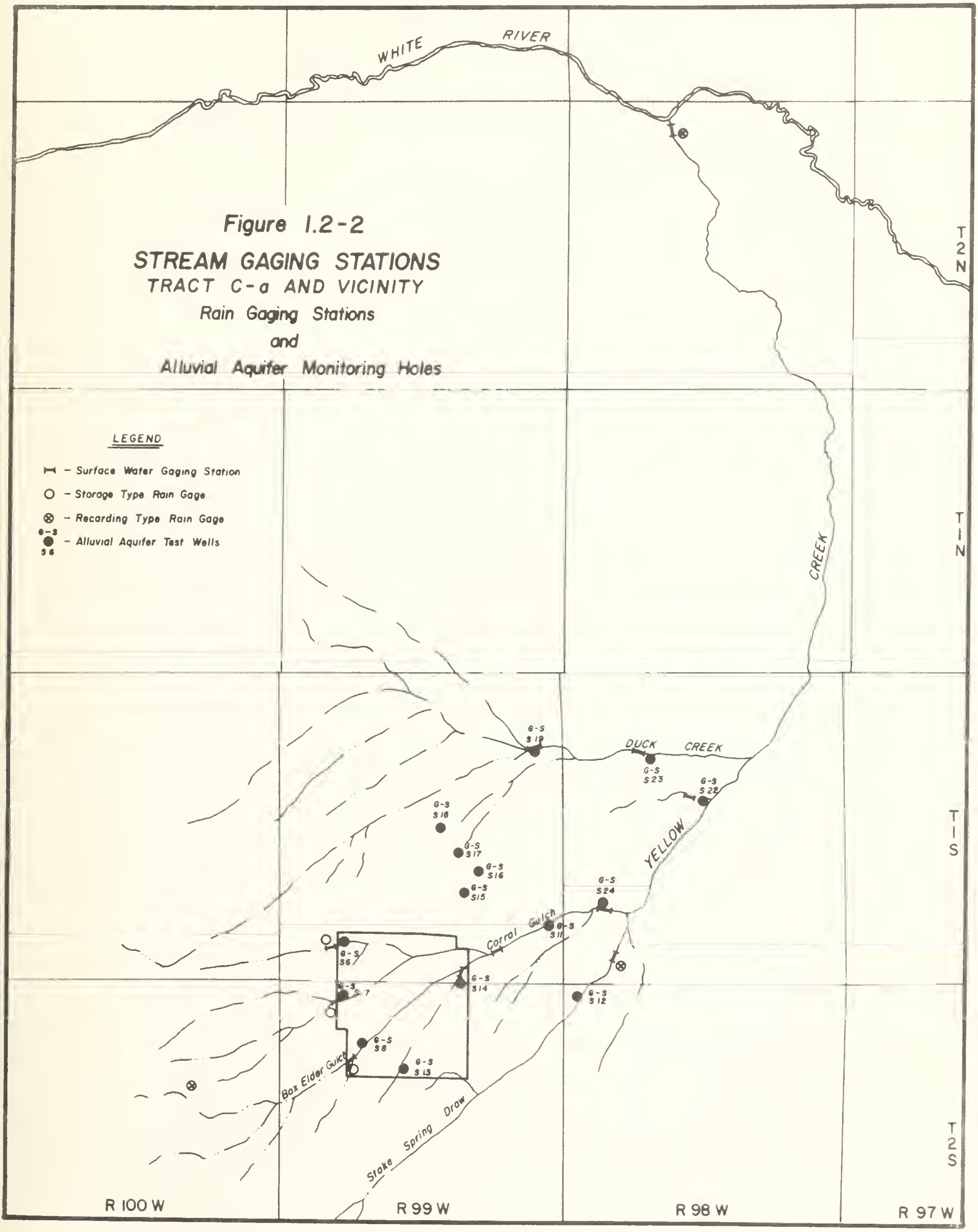


Figure 1.2-2

STREAM GAGING STATIONS
TRACT C-a AND VICINITY
Rain Gaging Stations
and
Alluvial Aquifer Monitoring Holes

Table 1.2-2

DATA COLLECTION SCHEDULE FOR STREAM GAGING STATIONS

TRACT C-a AND VICINITY

Continuously or Automatically

- Flow Rate
- Sediment Discharge
- Temperature
- Specific Conductance

Periodically

- Storage Rain Gages
- Recording Rain Gages

Semi-Monthly

- Barium
- Boron
- Calcium
- Chromium (Hexavalent)
- Copper
- Fluoride
- Iron
- Lithium
- Magnesium
- Potassium
- Selenium
- Silica
- Sodium
- Sulfate
- Zinc
- Ammonia
- Bicarbonate
- Carbonate
- Chloride
- Color
- Dissolved Solids
- Kjeldahl Nitrogen
- Nitrate
- Nitrite
- Odor
- Oil and Grease
- Turbidity
- Dissolved Oxygen
- pH
- Arsenic
- Cadmium
- Lead
- Manganese
- Mercury
- Total Phosphate
- Ortho Phosphate
- Cyanide
- Sulfide

Quarterly

- COD
- Fecal Coliform
- Pesticides
- Polycyclic Aromatics
- Radioactivity
  - Gross Alpha
    - 4 Picocuries/l
    - Ra^{226}
  - Gross Beta
    - 100 Picocuries/l
    - Th^{230}
    - Uranium
- Spectrographic Scan
  - 67 Elements
- TOC
  - 10 mg/l
  - DOC
  - SOC
  - Phenols
  - Sulfur
  - Nitrogen

Table 1.2-3
SUMMARY WATER ANALYSES
STREAM GAGING STATION, U.S.G.S. 09306235
CORRAL GULCH NEAR WEST LINE TRACT C-a

	3/12/75	3/16/75	4/9/75	4/23/75	5/14/75	5/28/75	6/11/75	6/24/75	7/15/7			
1. Alkalinity (mg/l)			324	301	291	322	318	305	312			
2. Aluminum (ug/l)			---	---	---	---	---	---	---			
3. Ammonia (mg/l)			.12	.00	.04	.00	.00	.05	.04			
4. Aromatics, Polycyclic			---		---							
5. Arsenic (ug/l)			4	5	4	9	4	4	4			
6. Barium (ug/l)			<100	0	100	0	100	0	200			
7. Beryllium (ug/l)			---		---							
8. Bicarbonate (mg/l)			395	367	355	393	388	372	380			
9. Bismuth (ug/l)			---		---							
10. Boron (ug/l)			90	100	90	90	90	100	80			
11. Cadmium (ug/l)			0	1	0	0	0	0	0			
12. Carbonate (mg/l)			0	0	0	0	0	0	0			
13. Carbon Dioxide (mg/l)			2.0	2.3	11	32	4.9	1.2	2.4			
14. Chloride (mg/l)			7.8	9.2	8.9	6.8	5.9	7.0	8.3			
15. Chromium (ug/l)			0	0	0	0	0	0	0			
16. Cobalt (ug/l)												
17. COD												
18. Coliform, Total & Fecal												
19. Color			9	3	10	7	8	8	15			
20. Conductivity, Specific			1080	1100	1100	900	1050	1100	1200			
21. Copper (ug/l)			8	3	2	1	-	4	0			
22. Cyanide (mg/l)			.00	.01	.01	.00	.00	.01	.00			
23. Discharge (CFS)												
24. Discharge, Instantaneous			.04	.03	.02	.10	---	.18	.10			
25. Dissolved Oxygen (mg/l)			---	7.0	8.7	9.1	5.6	6.4	7.0			
26. Fluoride (mg/l)			.2	.2	.2	.2	.3	.3	.3			
27. Gallium (ug/l)												
28. Germanium (ug/l)												
29. Hardness (Ca, Mg) (mg/l)			460	430	420	460	560	450	460			
30. Hardness, Non-Carbonate (mg/l)			140	130	130	140	140	140	150			
31. Iron (ug/l)			50	20	20	80	30	10	30			
32. Kjeldahl Nitrogen (mg/l)			4.2	.36	.30	1.0	.89	.25	.65			
33. Lead (ug/l)			0	3	1	2	0	2	0			
34. Lithium (ug/l)			20	10	20	20	10	20	10			
35. Magnesium (mg/l)			60	59	56	58	61	60	60			
36. Manganese (ug/l)			0	0	0	20	0	0	0			
37. Mercury (ug/l)			1.0	.0	.00	.0	.0	.0	.0			
38. Molybdenum (ug/l)			---		---							
39. Nickel (ug/l)			---		---							
40. Nitrate (mg/l)			4.3	2.8	2.2	4.4	6.6	5.3	4.0			
41. Nitrite (mg/l)			.00	.03	.00	.00	.03	.00	.03			
42. Nitrite Plus Nitrate (mg/l)			.98	.64	.50	1.0	1.5	1.2	.91			
43. Nitrogen, Ammonia			.09		.03							
44. Odor (Severity)			1	0	0	0	0	0	0			
45. Oil & Grease (mg/l)			3	---	0	2	1	3	4			
46. Ortho-Phosphate (mg/l)			.06	.06	.06	.06	.00	.03	.06			
47. Ortho-Phosphorus (mg/l)			.02	.02	.02	.02	.00	.01	.02			
48. Pesticides												
49. pH			8.5	8.4	7.7	7.3	8.1	8.7	8.4			
50. Phosphorus, Total (mg/l)			1.3	.06	.03	.07	.20	.01	.03			
51. Potassium (mg/l)			1.6	1.5	1.5	1.4	1.1	1.0	1.5			
52. Selenium (ug/l)			4	4	4	5	3	5	4			
53. Silica (mg/l)			19	20	18	19	23	22	21			
54. Silver (ug/l)			---		---							
55. Sodium (mg/l)			86	90	91	75	49	80	87			
56. Sodium Adsorption Ratio			1.7	1.9	1.9	1.5	1.0	1.6	1.8			
57. Sodium ( )			29	31	32	26	19	28	29			
58. Solids, Dissolved (mg/l)			729	719	719	709	663	699	734			
59. Solids, Dissolved T/D			.08	.06	.04	.19	---	.34	.20			
60. Solids, Dissolved T/Ac-Ft			.99	.98	.98	.96	.90	.95	1.00			
61. Solids, Suspended												
62. Strontium (ug/l)			---		---							
63. Sulfate (mg/l)			2.70	280	2.90	260	240	260	280			
64. Sulfide (mg/l)			.2	.0	.0	.0	.1	.0	.0			
65. Temperature (°C)			2.0	21.0	20.0	9.0	19.0	18.0	22.0			
66. Tin (ug/l)			---		---							
67. Titanium (ug/l)			---		---							
68. Turbidity JTU)			450	15	18	75	120	13	17			
69. Vanadium (ug/l)			---		---							
70. Zinc (ug/l)			20	0	10	0	10	6	0			
71. Zirconium (ug/l)			---		---							
72. Calcium (mg/l)			85		76							
73. Complete Element Span												
74. Radioactivity												
Gross Alpha (pci)												
Radium 226*												
Gross Beta												
Thorium 230**												
Uranium**												
75. Total Organic Carbon (mg/l)			---		---							
If TOC ·10 mg/liter, then												
Nitrogen (Base Extraction)												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extraction)												
76. Total Ortho-Phosphorous (mg/l)			.45	.01	.04	.01	.01	.02	.01			
77. Phosphate			---	.18	.09	.21	.61	.03	.09			

Table 1.2-4
SUMMARY WATER ANALYSES RBOSP
STREAM GAGING STATION U.S.G.S. 09306240
BOX ELDER GULCH NEAR WEST LINE TRACT C-a

	5/14/75	5/28/75	6/16/75	6/25/75								
1. Alkalinity (mg/l)	257	290	267	274								
2. Aluminum (ug/l)												
3. Ammonia (mg/l)	.01	.00	.00	.00								
4. Aromatics, Polycyclic												
5. Arsenic (ug/l)	8	5	5	3								
6. Barium (ug/l)	100	0	100	0								
7. Beryllium (ug/l)												
8. Bicarbonate (mg/l)	313	354	326	334								
9. Bismuth (ug/l)												
10. Boron (ug/l)	100	110	80	70								
11. Cadmium (ug/l)	0	0	0	0								
12. Carbonate (mg/l)	0	0	0	0								
13. Carbon Dioxide (mg/l)	1.6	---	.5	.8								
14. Chloride (mg/l)	6.0	5.2	5.2	6.0								
15. Chromium (ug/l)	20	0	0	0								
16. Cobalt (ug/l)												
17. COD												
18. Coliform, Total & Fecal												
19. Color	9	2	17	9								
20. Conductivity, Specific	845	880	800	800								
21. Copper (ug/l)	3	6	2	1								
22. Cyanide (mg/l)	.01	.00	.00	.01								
23. Discharge (CFS)												
24. Discharge, Instantaneous	.55	---	---	.49								
25. Dissolved Oxygen (mg/l)	5.5	8.8	8.3	8.0								
26. Fluoride (mg/l)	.3	.4	.3	.3								
27. Gallium (ug/l)												
28. Germanium (ug/l)												
29. Hardness (Ca, Mg) (mg/l)	340	380	350	340								
30. Hardness, Non-Carbonate (mg/l)	79	86	81	67								
31. Iron (ug/l)	20	40	10	0								
32. Kjeldahl Nitrogen (mg/l)	.37	2.7	.66	.31								
33. Lead (ug/l)	2	3	1	1								
34. Lithium (ug/l)	20	10	20	20								
35. Magnesium (mg/l)	49	46	47	44								
36. Manganese (ug/l)	5	20	0	5								
37. Mercury (ug/l)	.0	.0	.0	.0								
38. Molybdenum (ug/l)												
39. Nickel (ug/l)												
40. Nitrate (mg/l)	4.1	4.4	4.1	3.9								
41. Nitrite (mg/l)	.00	.00	.03	.03								
42. Nitrite Plus Nitrate (mg/l)	.92	1.0	.93	.89								
43. Nitrogen, Ammonia	.01	.00	.00	.00								
44. Odor (Severity)	0	0	0	0								
45. Oil & Grease (mg/l)	2	1	E2	3								
46. Ortho-Phosphate (mg/l)	.06	.09	.03	.03								
47. Ortho-Phosphorus (mg/l)	.02	.03	.01	.01								
48. Pesticides												
49. pH	8.5	---	9.0	8.8								
50. Phosphorus, Total (mg/l)	.12	.41	.03	.03								
51. Potassium (mg/l)	1.5	1.0	.7	.7								
52. Selenium (ug/l)	3	5	4	5								
53. Silica (mg/l)	23	21	22	23								
54. Silver (ug/l)												
55. Sodium (mg/l)	56	49	39	55								
56. Sodium Adsorption Ratio	1.3	1.1	.9	1.3								
57. Sodium (%)	27	22	20	26								
58. Solids, Dissolved (mg/l)	520	527	482	521								
59. Solids, Dissolved T/D	.77	---	---	.69								
60. Solids, Dissolved T/Ac-Ft	.71	.72	.66	.71								
61. Solids, Suspended												
62. Strontium (ug/l)												
63. Sulfate (mg/l)	170	150	140	160								
64. Sulfide (mg/l)	.0	.2	.2	.0								
65. Temperature (°C)	27.5	8.5	19.0	12.5								
66. Tin (ug/l)												
67. Titanium (ug/l)												
68. Turbidity JTU)	50	210	32	13								
69. Vanadium (ug/l)												
70. Zinc (ug/l)	0	10	10	0								
71. Zirconium (ug/l)												
72. Calcium (mg/l)												
73. Complete Element Span												
74. Radioactivity												
Gross Alpha (pci)												
Radium 226*												
Gross Beta												
Thorium 230**												
Uranium**												
75. Total Organic Carbon (mg/l)												
If TOC 10 mg/liter, then												
Nitrogen (Base Extraction)												
Organic Carbon, Dissolved												
Organic Carbon, Suspended												
Phenols												
Sulfur (Acid Extraction)												
76. Total Ortho-Phosphorous (mg/l)	.03	.04	.01	.01								
77. Phosphate	.37	1.3	.09	.09								

Table 1.2-5
SUMMARY WATER ANALYSES
STREAM GAGING STATION U.S.G.S. 09306242
CORRAL GULCH EAST OF TRACT C-a

	Date Time	2/12/75 1100	3/26/75 1415	4/9/75 1045	4/9/75 1100	4/23/75 1100	5/14/75 1245	5/28/75 1430	6/11/75 1545	6/24/75 1450	7/15/75 1230	7/30/75 1110	
1.	Alkalinity (mg/l)	417	---	---	739	503	421	668	378	401	389	381	
2.	Aluminum (ug/l)	20	---	---	---	---	---	---	---	---	---	---	
3.	Ammonia (mg/l)	.28	---	---	.35	.15	.03	.22	.00	.00	.04	.00	
4.	Aromatics, Polycyclic												
5.	Arsenic (ug/l)	6	---	---	7	2	5	9	4	3	5	6	
6.	Barium (ug/l)	50	---	---	<100	0	0	100	100	0	100	0	
7.	Beryllium (ug/l)	<2	---	---	---	---	---	---	---	---	---	---	
8.	Bicarbonate (mg/l)	508	---	---	901	735	513	815	461	489	474	464	
9.	Bismuth (ug/l)	<5	---	---	---	---	---	---	---	---	---	---	
10.	Boron (ug/l)	100	---	---	320	550	160	670	150	160	140	120	
11.	Cadmium (ug/l)	60	---	---	0	1	1	0	0	0	0	3	
12.	Carbonate (mg/l)	0	---	---	0	0	0	0	0	0	0	0	
13.	Carbon Dioxide (mg/l)	13	---	---	7.2	7.4	65	13	7.4	4.9	4.8	.9	
14.	Chloride (mg/l)	8.9	---	---	11	16	11	15	8.8	9.7	11	10	
15.	Chromium (ug/l)	<5	---	---	0	0	0	0	0	0	0	0	
16.	Cobalt (ug/l)	<5	---	---	---	---	---	---	---	---	---	---	
17.	COD	94	---	---	---	---	---	---					
18.	Coliform, Total & Fecal												
19.	Color	8	---	---	5	0	5	6	17	10	6	6	
20.	Conductivity, Specific	1200	---	---	1725	1550	1300	1550	1100	1200	1000	1150	
21.	Copper (ug/l)	2	---	---	3	6	1	1	0	1	0	4	
22.	Cyanide (mg/l)	.00	---	---	.00	.01	.01	.02	.02	.01	.00	.00	
23.	Discharge (CFS)												
24.	Discharge, Instantaneous	.34	---	---	1.1	1.3	.46	3.1	---	1.5	1.1	1.0	
25.	Dissolved Oxygen (mg/l)	9.0	---	5.4	5.4	7.3	8.0	8.1	5.0	4.8	6.7	7.6	
26.	Fluoride (mg/l)	.4	---	---	10	4.3	.4	2.8	.5	.5	.5	.6	
27.	Gallium (ug/l)	<2	---	---	---	---	---	---	---	---	---	---	
28.	Germanium (ug/l)	<6	---	---	---	---	---	---	---	---	---	---	
29.	Hardness (Ca, Mg) (mg/l)	520	---	---	360	380	480	390	420	410	430	460	
30.	Hardness, Non-Carbonate (mg/l)	98	---	---	0	0	58	0	42	6	37	75	
31.	Iron (ug/l)	120	---	---	30	10	30	30	70	0	20	10	
32.	Kjeldahl Nitrogen (mg/l)	.67	---	---	2.4	1.1	.14	2.2	.67	.30	.52	.30	
33.	Lead (ug/l)	<5	---	---	2	8	1	1	0	1	0	3	
34.	Lithium (ug/l)	14	---	---	30	20	10	20	10	10	0	10	
35.	Magnesium (mg/l)	70	---	---	52	59	63	53	56	54	55	64	
36.	Manganese (ug/l)	43	---	---	0	70	20	6	0	5	0	0	
37.	Mercury (ug/l)	.0	---	---	.3	0	0	0	.0	.0	.0	.0	
38.	Molybdenum (ug/l)	30	---	---	---	---	---	---	---	---	---	---	
39.	Nickel (ug/l)	<4	---	---	---	---	---	---	---	---	---	---	
40.	Nitrate (mg/l)	1.2	---	---	1.2	1.5	1.4	3.0	3.0	2.5	1.6	1.5	
41.	Nitrite (mg/l)	.07	---	---	.00	.10	.00	.03	0.3	.03	.03	.03	
42.	Nitrite Plus Nitrate (mg/l)	.28	---	---	.28	.36	.32	.68	.69	.57	.37	.34	
43.	Nitrogen, Ammonia	.22	---	---	.27	.12	.02	.17	.00	.00	.03	.00	
44	Odor (Severity)	3	2	2	---	0	0	1	0	0	0	1	
45.	Oil & Grease (mg/l)	4	---	---	2	3	0	2	2	3	2	1	
46.	Ortho-Phosphate (mg/l)	.28	---	---	.06	.12	.15	.12	.00	.06	.15	.03	
47.	Ortho-Phosphorus (mg/l)	.09	---	---	.02	.04	.05	.04	.00	.02	.05	.01	
48.	Pesticides												
49.	pH	7.8	---	---	8.3	8.2	7.1	8.0	8.0	8.2	8.2	8.9	
50.	Phosphorus, Total (mg/l)	.37	---	---	.60	.58	.05	.41	.54	.07	.04	.04	
51.	Potassium (mg/l)	1.4	---	---	2.3	2.0	1.8	2.2	1.4	1.4	1.4	1.6	
52.	Selenium (ug/l)	2	---	---	2	1	2	2	3	4	3	3	
53.	Silica (mg/l)	13	---	---	19	19	21	20	23	21	21	22	
54.	Silver (ug/l)	0	---	---	---	---	---	---	---	---	---	---	
55.	Sodium (mg/l)	110	---	---	300	240	120	250	94	110	110	110	
56.	Sodium Adsorption Ratio	2.1	---	---	6.8	5.4	2.4	5.5	2.0	2.4	2.2	2.2	
57.	Sodium (%)	32	---	---	64	58	35	58	33	37	36	34	
58.	Solids, Dissolved (mg/l)	838	---	---	1140	1040	850	1020	691	724	775	770	
59.	Solids, Dissolved T/D	.77	---	---	3.57	3.73	1.06	3.54	---	2.97	2.34	2.24	
60.	Solids, Dissolved T/Ac-Ft	1.14	---	---	1.55	1.41	1.16	1.39	.94	.98	1.05	1.06	
61.	Solids, Suspended												
62.	Strontium (ug/l)	1600	---	---	---	---	---	---	---	---	---	---	
63.	Sulfate (mg/l)	290	---	---	240	280	290	200	200	210	260	260	
64.	Sulfide (mg/l)	.0	---	---	.3	.0	.2	.2	.2	.0	.0	.0	
65.	Temperature (°C)	8.0	---	---	7.0	13.0	14.0	11.0	19.0	15.0	15.0	17.0	
66.	Tin (ug/l)	<5	---	---	---	---	---	---	---	---	---	---	
67.	Titanium (ug/l)	<4	---	---	---	---	---	---					
68.	Turbidity JTU)	1000	---	---	740	50	1	120	150	50	13	4	
69.	Vanadium (ug/l)	3.0	---	---	---	---	---	---	---	---	---	---	
70.	Zinc (ug/l)	0	---	---	40	10	6	10	10	4	0	20	
71.	Zirconium (ug/l)	<9	---	---	---	---	---	---					
72.	Calcium (mg/l)	90	---	---	60	55	88	68					
73.	Complete Element Span												
74.	Radioactivity												
	Gross Alpha (pci)	<10	---	---	---	---	---	---					
	Radium 226*												
	Gross Beta	<2.4	---	---	---	---	---	---					
	Thorium 230**												
	Uranium**												
75.	Total Organic Carbon (mg/l)	9.8	---	---	---	---	---	---					
	If TOC >10 mg/liter, then												
	Nitrogen (Base Extraction)												
	Organic Carbon, Dissolved												
	Organic Carbon, Suspended												
	Phenols												
	Sulfur (Acid Extraction)												
76.	Total Ortho-Phosphorus	.11	---	---	.58	.05	.06	.04	.04	.03	.01	.04	
77.	Phosphate	---	---	---	---	1.8	.15	1.3	1.7	.21	.12	.12	

Table 1.2-6

SUMMARY WATER ANALYSES RBOSP
STREAM GAGING STATION U.S.G.S. 09306255
YELLOW CREEK NEAR WHITE RIVER

	Date	3/12/75	3/26/75	4/9/75	4/9/75	4/23/75	5/15/75	5/28/75	6/13/75	6/26/75	7/16/75	7/29/75	8/14/75
	Time	1400	1030	1200	1300	1000	1100	1115	1115	1330	1045	0920	0915
1.	Alkalinity (mg/1)	1330	1330	1380	1580	1220	1380	1270	1460	1500	1280	1580	1510
2.	Aluminum (ug/1)	150	---	---	---	---	---						
3.	Ammonia (mg/1)	.00	.22	.24	.30	.00	.08	.00	.01	.03	.00	.05	.00
4.	Aromatics, Polycyclic												
5.	Arsenic (ug/1)	5	3	1	5	6	5	5	5	9	6	4	6
6.	Barium (ug/1)	200	100	<100	300	0	300	200	300	200	400	0	400
7.	Beryllium (ug/1)	<4	---	---	---	---	---						
8.	Bicarbonate (mg/1)	1620	1210	1480	930	1490	1510	1150	1490	1550	1340	596	1220
9.	Bismuth (ug/1)	<15	---	---	---	---	---						
10.	Boron (ug/1)	560	630	680	700	630	640	640	730	740	670	690	720
11.	Cadmium (ug/1)	<170	0	0	0	1	2	1	0	0	1	1	0
12.	Carbonate (mg/1)	0	203	97	0	1	87	194	140	139	107	657	308
13.	Carbon Dioxide (mg/1)	10	5.2	4.3	6.2	3.8	5.4	---	1.1	2.3	7.9	3.9	12
14.	Chloride (mg/1)	130	110	130	130	120	120	100	130	130	110	140	140
15.	Chromium (ug/1)	<15	0	0	0	0	0	0	0	0	0	0	0
16.	Cobalt (ug/1)	<15	---	---	---	---	---						
17.	COO	7	---	---	---	---	---						
18.	Coliform, Total & Fecal												
19.	Color	3	10	3	2	4	3	20	20	20	45	20	20
20.	Conductivity, Specific	3500	3600	3250	3400	3500	3000	3020	4000	4200	3800	3500	4000
21	Copper (ug/1)	5	0	3	1	7	3	2	1	3	4	4	2
22	Cyanide (mg/1)	.00	.00	---	.00	.00	.00	.00	.00	.00	.00	.00	.00
23.	Discharge (CFS)	---	---	---	---	---	---						
24.	Discharge, Instantaneous	2.9	2.2	1.2	3.3	1.9	1.7	---	---	1.1	1.9	1.1	---
25.	Dissolved Oxygen (mg/1)	8.5	10.6	10.4	9.1	9.6	7.6	9.7	8.6	8.4	7.4	11.0	8.1
26.	Fluoride (mg/1)	2.0	1.9	1.2	1.6	2.1	2.1	2.0	2.4	2.4	1.8	2.5	2.2
27.	Gallium (ug/1)	<5	---	---	---	---	---						
28.	Germanium (ug/1)	<20	---	---	---	---	---						
29.	Hardness (Ca, Mg) (mg/1)	550	650	500	590	550	570	500	550	500	500	490	510
30.	Hardness, Non-Carbonate (mg/1)	0	0	0	0	0	0	0	0	0	0	0	0
31.	Iron (ug/1)	65	20	10	10	30	40	660	20	10	20	90	10
32	Kjeldahl Nitrogen (mg/1)	.17	.71	---	2.6	.60	.30	1.4	.98	.45	.86	.57	.52
33.	Lead (ug/1)	<16	0	0	0	9	4	5	1	1	0	2	1
34.	Lithium (ug/1)	160	120	120	140	130	170	120	170	160	130	160	160
35.	Magnesium (mg/1)	110	130	98	120	130	120	100	120	110	96	110	110
36	Manganese (ug/1)	14	20	10	10	30	10	50	0	0	0	20	10
37.	Mercury (ug/1)	.0	.0	.3	.0	.0	.2	.0	.0	0	0	.0	.0
38.	Molybdenum (ug/1)	30	---	---	---	--	---						
39.	Nickel (ug/1)	<10	---	---	---	- -	---						
40.	Nitrate (mg/1)	9.3	6.6	9.7	7.9	4.4	2.5	1.5	.04	.49	2.2	4.4	1.2
41.	Nitrite (mg/1)	.00	.03	.03	.03	.03	.03	.03	.00	.07	.03	.03	.20
42	Nitrite Plus Nitrate (mg/1)	2.1	1.5	2.2	1.8	1.0	.58	.35	01	13	.51	1.0	.34
43.	Nitrogen, Ammonia	.00	.17	.19	.23	.00	.06	.00	.01	.02	.00	.04	.00
44	Odor (Severity)	2	2	---	---	0	0	0	0	0	0	0	0
45.	Oil & Grease (mg/1)	3	3	---	2	2	1	1	0	---	1	E1	0
46.	Ortho-Phosphate (mg/1)	.15	.37	.34	.15	.12	.06	.06	.00	.03	.00	.00	.00
47.	Ortho-Phosphorus (mg/1)	.05	.12	.11	.05	.04	.02	.02	.00	.01	.00	.00	.00
48.	Pesticides												
49.	pH	8.4	8.7	8.8	8.7	8.8	8.7	---	9.4	9.1	8.5	8.9	8.4
50.	Phosphorus, Total (mg/1)	.02	.13	---	.79	.09	.04	.10	.01	.01	.24	.03	.05
51	Potassium (mg/1)	4.6	3.5	3.8	4.4	7.4	3.9	4.5	3.5	3.6	5.5	3.9	5.0
52	Selenium (ug/1)	3	2	3	3	1	1	3	2	2	2	2	3
53	Silica (mg/1)	20	14	14	14	11	7.1	5.7	1.9	3.7	14	.3	1.1
54	Silver (ug/1)	<2	---	---	---	---	---						
55	Sodium (mg/1)	710	700	680	840	710	740	680	780	780	700	810	800
56	Sodium Adsorption Ratio	13	12	13	15	13	13	13	15	15	14	16	15
57.	Sodium (%)	74	70	75	75	73	74	74	76	77	75	78	77
58.	Solids, Dissolved (mg/1)	2320	2450	2270	2740	2330	2430	2250	2540	2530	2280	2550	2520
59.	Solids, Dissolved T/D	18.6	14.6	7.66	25.0	12.0	11.2	---	---	7.51	12.1	7.57	---
60.	Solids, Dissolved T/Ac-Ft	3.16	3.33	3.09	3.73	3.17	3.30	3.06	3.45	3.44	3.10	3.47	3.43
61.	Solids, Suspended												
62.	Strontium (ug/1)	3500	---	---	---								
63.	Sulfate (mg/1)	490	640	470	630	600	570	560	600	580	540	510	530
64.	Sulfide (mg/1)	.0	.1	.3	.2	.1	.1	.0	.3	.3	.1	.0	.0
65.	Temperature (°C)	9.0	3.5	6.0	9.0	9.0	17.0	9.5	21.5	24.0	19.0	17.0	14.0
66.	Tin (ug/1)	<15	---	---	---	---	---						
67.	Titanium (ug/1)	<10	---	---	---	---	---						
68.	Turbidity (JTU)	3	85	3	400	56	18	230	23	4	150	12	44
69.	Vanadium (ug/1)	<8.0	---	---	---	---	---						
70.	Zinc (ug/1)	6	0	6	20	0	6	30	10	10	20	40	10
71	Zirconium (ug/1)	<25	---	---	---	---	---						
72.	Calcium (mg/1)	37	45	37	40	7.0	31						
73.	Complete Element Span												
74.	Radioactivity												
	Gross Alpha (pci)	<36	---	---	---	---	---						
	Radium 226*												
	Gross Beta	8.8	---	---	---	---	---						
	Thorium 230**												
	Uranium**												
75.	Total Organic Carbon (mg/1)	4.7	---	---	---	---	---						
	If TOC 10 mg/liter, then												
	Nitrogen (Base Extraction)												
	Organic Carbon, Dissolved												
	Organic Carbon, Suspended												
	Phenols												
	Sulfur (Acid Extraction)												
76.	Total Ortho-Phosphorous (mg/1)	.06	.12	.30	.42	.01	.01	.02	.01	.01	.05	.00	.02
77.	Phosphate	---	---	---	---	28	.12	.31	.03	.03	.74	.09	.15
78.	Phosphorus, Dissolved	---	---	---	---	---	---	---	---	---	---	---	---

Discharge at Corral Gulch east of the Tract has declined from a high of about 3 cubic feet per second (cfs) recorded during spring runoff and lower aquifer pumping in May to a median level of about 1.2 cfs. Discharge at the stream gaging station on Corral Gulch near the west line of Tract C-a showed a broad increase from mid-May through late June. A peak value for that stream gage of about 0.2 cfs was reported in late June, an increase from a low of less than .01 cfs. The last recorded value for Corral Gulch near the west line of Tract C-a is 0.1 cfs and indicated a trend toward the barely detectable amount. Discharge at the Yellow Creek gaging station has been quite variable with a decline from a high of 3.3 cfs to a low of about 1.1 cfs in June. A rapid increase from the 1.1 cfs flow in June to a 1.7 cfs flow in mid-July followed by a rapid decrease to the 1.1 cfs level was observed for the Yellow Creek stream gaging station.

Conductivity at the stream gaging station on Corral Gulch near the west line of Tract C-a dropped slightly in late May from 1100 umhos/cm to 980 umhos/cm. It then increased to 1100 umhos/cm by mid-July. Conductivity at the stream gage on Corral Gulch east of Tract C-a decreased from 1500 umhos/cm in late May to 1100 umhos/cm in late July. The station on Yellow Creek has indicated variable conductivity. It rose from a low of 3000 umhos/cm to a peak value of 4200 umhos/cm in late June. This was followed by a downward trend to 3500 umhos/cm by mid-July and then an upward trend to 400 umhos/cm by mid-August.

Values for boron have been stable and close to the corresponding median values for the stream gage on Yellow Creek and both stream gages on Corral Gulch. The boron values on Yellow Creek is about 0.7 parts per million (ppm). The boron concentration on Corral Gulch east of Tract C-a fluctuated from 0.2 ppm to 0.7 ppm. The boron values on Corral Gulch near the west line of Tract C-a were stable around 0.1 ppm.

The fluoride concentration at the stream gage on Corral Gulch near the west line of Tract C-a has been stable at 0.3 ppm from late May through July. The fluoride values for Corral Gulch east of Tract C-a have shown wide variations. Values fluctuated from 0.4 ppm to 2.8 ppm in May with a rapid decrease to a stable value of 0.5 ppm by mid-June. This variation is almost certainly related to discharge from pumping tests of high fluoride water from the lower aquifer. The Yellow Creek stream gaging station indicated a fluctuation in fluoride content from 1.8 ppm to 2.5 ppm from late May to late July. Plots of the conductivity, discharge, boron concentration and fluoride concentration for the four stream gaging stations are presented in section 1.2.2 of RBOSP Progress Report 4 -

Interpretive Text. Figure 1.2-3 is a sample plot of the conductivity and discharge; figure 1.2-4 is a sample plot of the concentrations of boron and fluoride presented for each of the stream gaging stations recording flow.

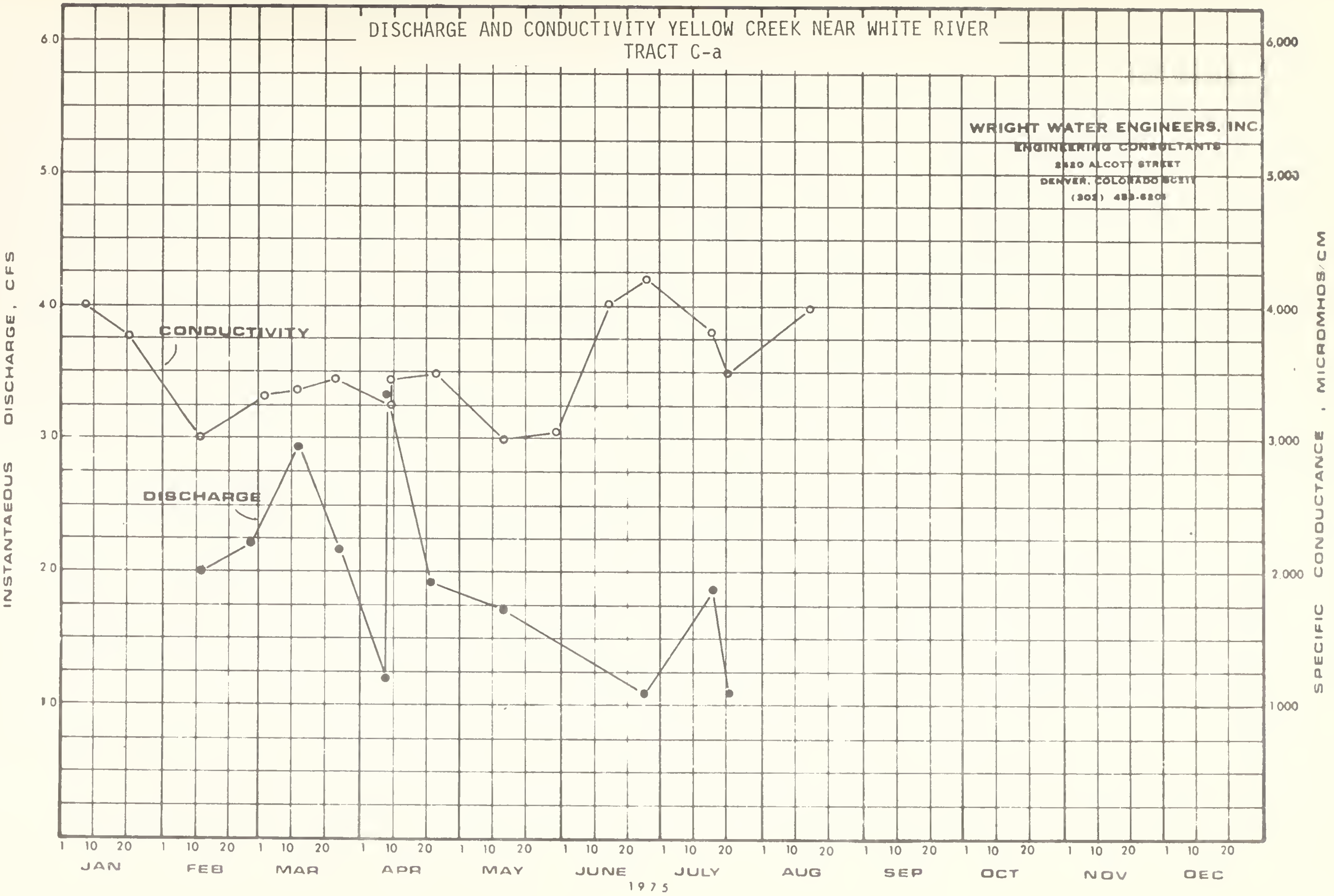
The two types of rain gages collecting precipitation data were described in RBOSP Progress Report 2. The three storage type rain gages, located at the stream gaging stations on Dry Fork, Corral Gulch, and Box Elder Gulch, near the west line of Tract C-a (see Figure 1.2-2) average 0.5 inches of precipitation in storage during the period from the first of January to July 1975. The Dry Fork and Corral Gulch rain gages indicated that peak amounts occurred during the month of May 1975. The Box Elder rain gage indicated maximum precipitation between March and April 1975. Differences in time for peak amounts indicates that precipitation is from localized events. Correlation between the storage rain gages shows a dry period in early July when no precipitation was recorded on Dry Fork or Box Elder Gulch. The storage rain gage on Corral Gulch indicated that precipitation during the same period there was below average. RBOSP Progress Report 4 - Interpretive Text section 1.2.2 contains historgram plots of all three storage type rain gages from the data presently available. Figure 1.2-5 is an example plot of storage rain gage data.

Two of the three recording type rain gages are located at the stream gaging stations on Stake Springs Draw near the confluence with Corral Gulch and Yellow Creek near the White River. The third recording type rain gage is located near Cathedral Bluffs directly west of Tract C-a. The Cathedral Bluffs rain gage malfunctioned from June to July with a resultant loss of data for that period. Correlation between gaging stations on Stake Springs Draw and Yellow Creek indicates a lower rate of instantaneous precipitation during June than in May. The recording rain gages recorded peak instantaneous precipitation during mid-July. The Stake Springs Draw gaging station recorded a high of 1.19 inches of precipitation in 24 hours during that period. During that same 24-hour period, the Yellow Creek rain gage recorded only 0.48 inches of precipitation. The variation in rainfall is attributable to the localized nature of large thunderstorms. Figure 1.2-6 is a sample histogram plot of the data collected from the recording type rain gages.

1.2.3 Alluvial Aquifers

RBOSP Progress Report 2 described in detail the drilling and completion of seven alluvial test holes. Additional data was also included in RBOSP Progress Report 3.

Figure 1.2-3



DISCHARGE AND CONDUCTIVITY YELLOW CREEK NEAR WHITE RIVER
TRACT C-a

Figure 1.2-4

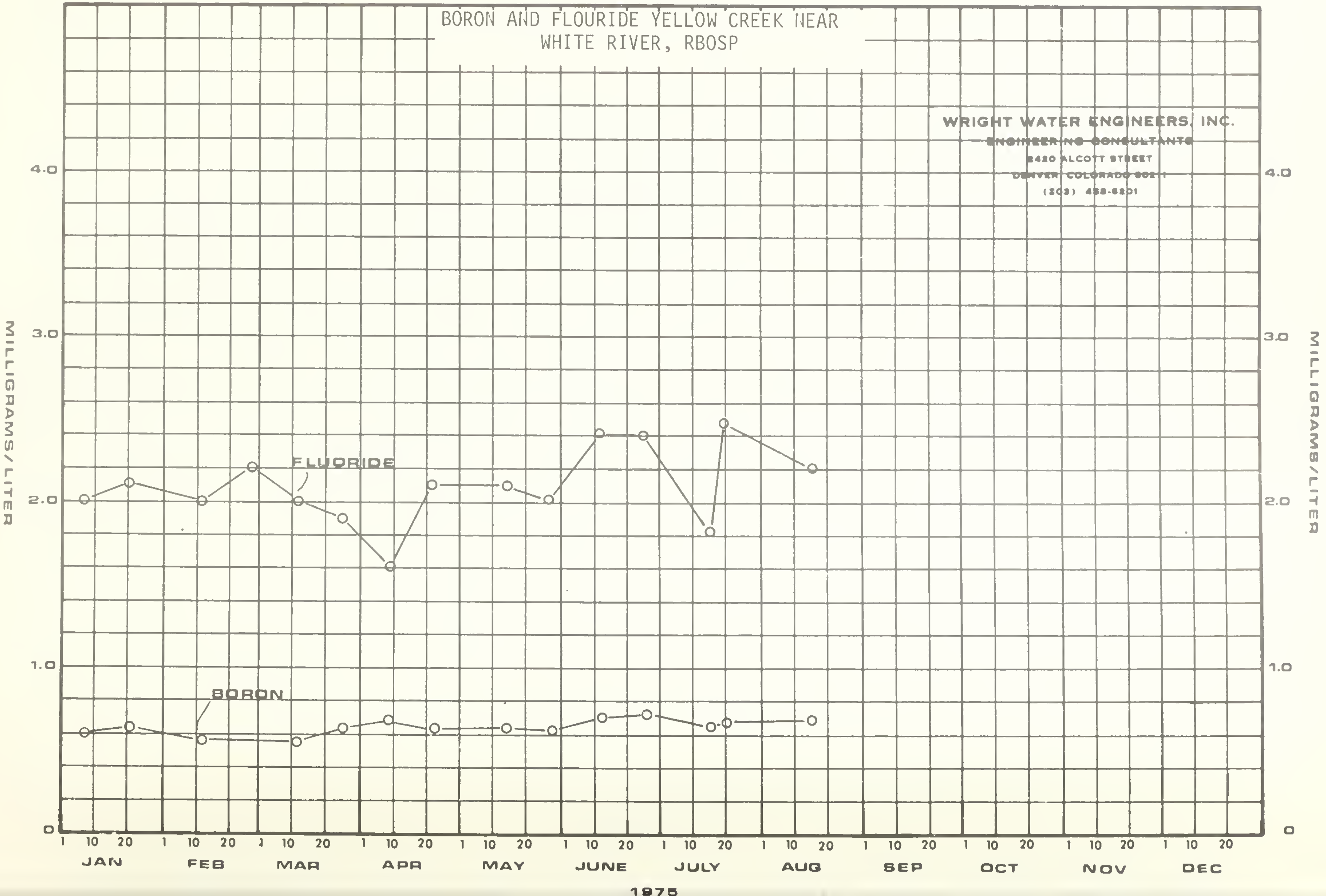
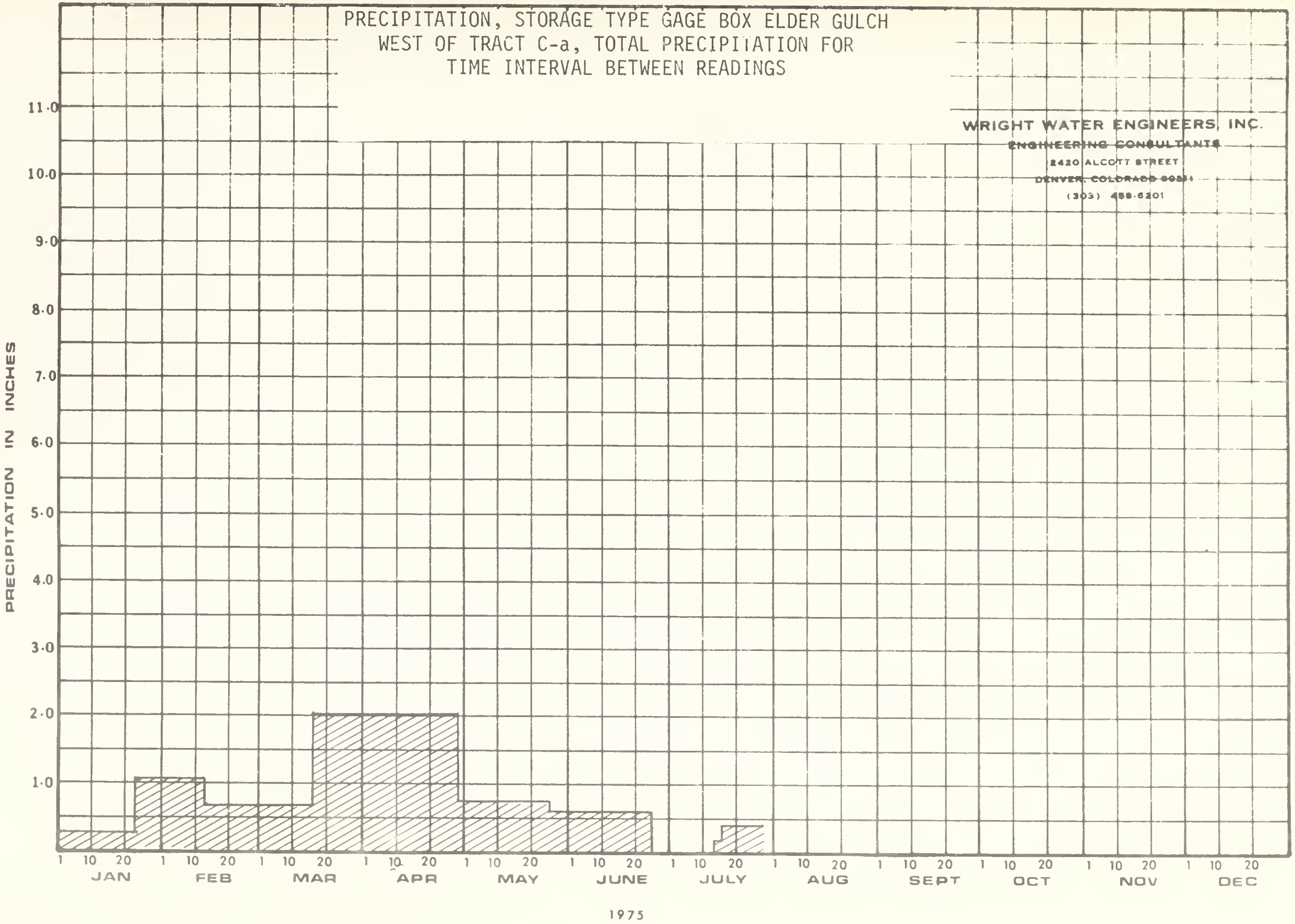
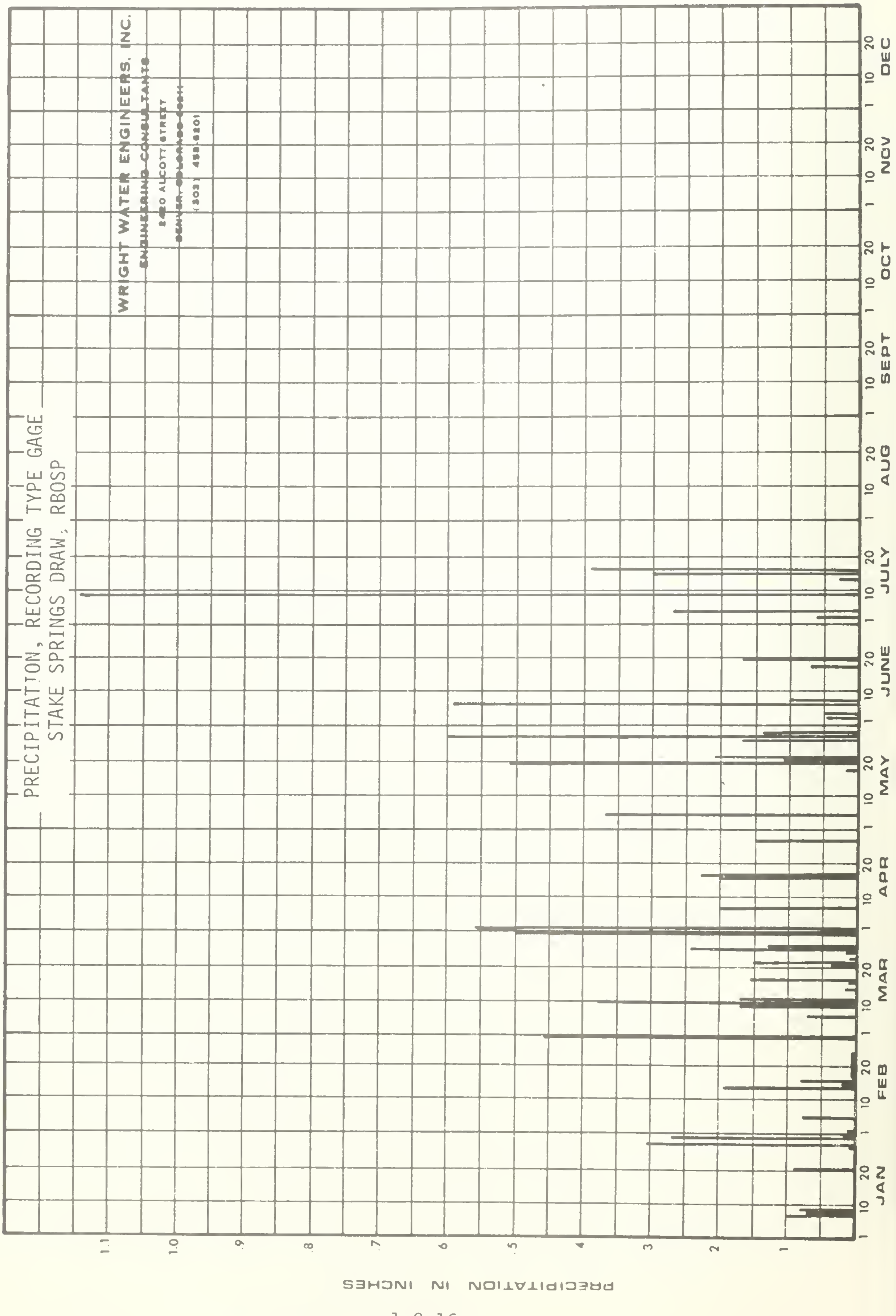

BORON AND FLOURIDE YELLOW CREEK NEAR WHITE RIVER, RBOSP

Figure 1.2-5



PRECIPITATION, STORAGE TYPE GAGE BOX ELDER GULCH
WEST OF TRACT C-a, TOTAL PRECIPITATION FOR
TIME INTERVAL BETWEEN READINGS

Figure 1.2-6



PRECIPITATION, RECORDING TYPE GAGE
STAKE SPRINGS DRAW, RBOSP

During the quarterly reporting period, eight additional alluvial water monitoring holes were drilled and completed. The purpose of the program, begun June 18 and finished July 16, 1975, was to establish baseline alluvial aquifer data for the 84 Mesa area. Figure 1.2-2, shows the locations of the eight recently-drilled holes as well as the seven earlier alluvial test holes. The new holes are designated: G-S S15, G-S S16, G-S 17, G-S S18, G-S S19, G-S S22, G-S S23 and G-S S24. Only four of the new holes encountered water: G-S S19, G-S S22, G-S S23 and G-S S24. The first water samples from these holes were collected on June 30. A more detailed description of this drilling program is presented in section 1.2.3 of RBOSP Progress Report 4 - Interpretive Text, and a program report by the groundwater geologist is included in RBOSP Progress Report 4 - Interpretive Text Appendix.

Thickness of alluvium in the eight recently drilled test holes varies from about 10 feet to 90 feet, the thinner alluvium being present along the smaller tributaries. Water quality measured during the alluvial test hole drilling program ranged: in temperature, from 10.5°C to 12.1°C; in specific conductance, from 1910 to 2275 umhos/cm; and in pH, from 6.8 to 7.0.

Monitoring of the seven original alluvial test holes showed a rising water level during the months of May and June. Since the alluvial aquifers are closely related to the surface water system, the rise in water level is thought to be due to the increased runoff from spring snowmelt.

Table 1.2-7 and table 1.2-8 are summaries of the wet chemical and spectographic analyses, respectively, of samples obtained from the alluvial aquifer monitoring program. Figure 1.2-7 is a sample plot of the water depth and conductivity data from the monitoring of an alluvial test hole. Figure 1.2-8 is a sample plot of the temperature and pH data obtained from the monitoring of an alluvial test hole. Plots of water level and conductivity versus time and temperature and pH versus time are presented in section 1.2.3 of RBOSP Progress Report 4 - Interpretive Text for all eight of the alluvial aquifer test holes in which water was present and sampled.

1.2.4 Deep Aquifer Drilling Program

The deep aquifer drilling completed in conjunction with the corehole program of the Geologic Program was described in detail in RBOSP Progress Report 2. During the quarter an

TABLE 1.2-7

WATER QUALITY ANALYSIS SUMMARY

WET CHEMICAL ANALYSIS.

ALLUVIAL AQUIFERS

(mg/l)

Item	Low	High	Average	No. Items Averaged
Alkalinity	329.000	615.000	469.308	49
Aluminum	< 0.100	< 0.100	0.0	4
Ammonia	< 0.100	1.000	0.287	39
Arsenic	< 0.010	0.010	0.000	49
Barium	< 1.000	< 1.000	0.0	49
Bicarbondate	370.000	750.000	566.735	49
Boron	< 0.010	27.000	1.783	49
Cadmium	< 0.010	0.090	0.009	49
Calcium	28.000	210.000	99.163	49
Carbonate	< 0.100	54.000	5.510	49
Chloride	6.800	71.000	17.698	49
Chromium	< 0.050	< 0.010	0.0	49
Conductance	860.000	2370.000	1565.518	49
Copper	< 0.100	0.300	0.033	49
Cyanide	< 0.010	0.010	0.001	49
Dissolved Solids	640.000	1670.000	1134.592	49
Fluoride	< 0.100	0.800	0.333	48
Gross Alpha	1.400	17.000	8.764	28
Gross Beta	1.000	12.000	6.250	4
Hardness	280.000	765.000	570.816	49
Hydroxide	--	--	0.0	0
Iron	< 0.050	28.000	8.018	49
Lead	0.020	0.800	0.214	49
Lithium	--	--	0.0	0
Magnesium	3.700	874.000	94.939	49
Manganese	< 0.050	14.000	2.298	49
Mercury	< 0.010	0.002	0.000	49
Nickel	0.010	0.200	0.049	49
Nitrate	< 0.100	21.000	5.106	49
pH	6.000	7.200	6.665	49
Phosphate	< 0.100	0.200	0.010	49
Potassium	--	--	0.0	0
Selenium	< 0.100	< 0.010	0.0	49
Silicon Dioxide	22.000	44.000	32.327	49
Silver	< 0.100	0.070	0.003	49
Sodium	75.000	310.000	191.531	49
Sulfate	145.000	780.000	423.877	49
Sulfide	--	--	0.0	0
TOC	7.000	100.000	33.100	20
Zinc	< 0.100	5.700	0.625	48

TABLE 1.2-8

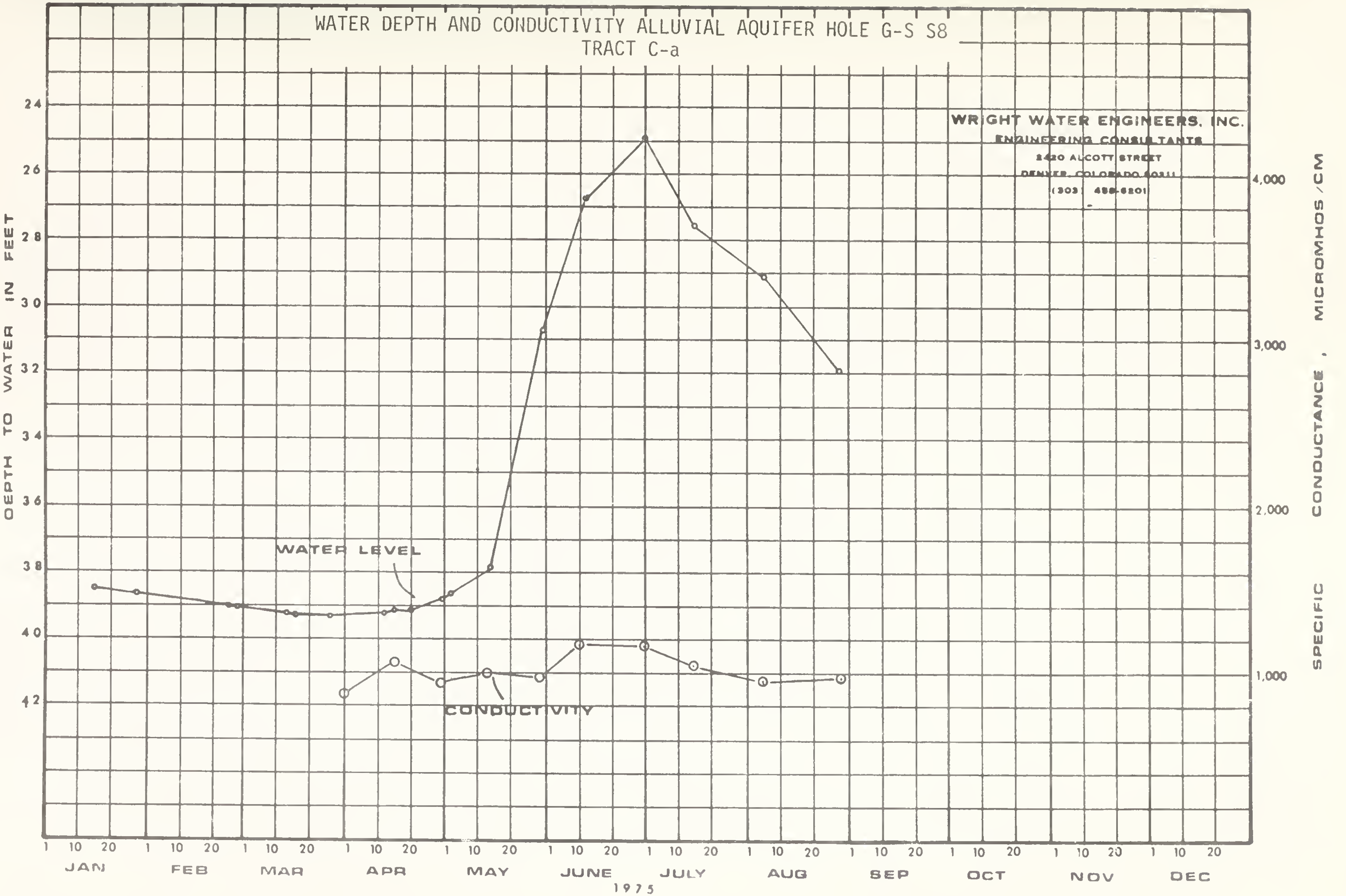
SUMMARY OF QUALITATIVE SPECTROGRAPHIC ANALYSIS
ALLUVIAL AQUIFERS
(mg/l)

Item	Low	High	Average	No. Items Averaged
Aluminum	0.050	0.500	0.161	9
Antimony	--	--	0.0	0
Arsenic	--	--	0.0	0
Barium	--	--	0.0	0
Beryllium	--	--	0.0	0
Bismuth	--	--	0.0	0
Boron	0.100	0.500	0.267	9
Cadmium	--	--	0.0	0
Calcium	99999.000	99999.000	0.0	0
Cerium	--	--	0.0	0
Cesium	0.001	0.001	0.001	1
Chromium	0.000	0.000	0.000	1
Cobolt	--	--	0.0	0
Columbium	--	--	0.0	0
Copper	0.001	0.010	0.004	8
Dysprosium	--	--	0.0	0
Erbium	--	--	0.0	0
Europium	--	--	0.0	0
Gadolinium	--	--	0.0	0
Gallium	--	--	0.0	0
Germanium	--	--	0.0	0
Gold	--	--	0.0	0
Hanium	--	--	0.0	0
Holmium	--	--	0.0	0
Indium	--	--	0.0	0
Iridium	--	--	0.0	0
Iron	0.010	0.100	0.044	9
Lanthanum	--	--	0.0	0
Lead	0.001	0.001	0.001	3
Lithium	0.001	0.100	0.042	5
Lutetium	--	--	0.0	0
Magnesium	999999.000	99999.000	0.0	0
Manganese	0.001	0.100	0.017	9
Mercury	--	--	0.0	0
Molybdenum	0.001	0.050	0.016	8
Neodymium	--	--	0.0	0
Nickel	--	--	0.0	0
Osmium	--	--	0.0	0
Palladium	--	--	0.0	0
Platinum	--	--	0.0	0

TABLE 1.2-8
Continued

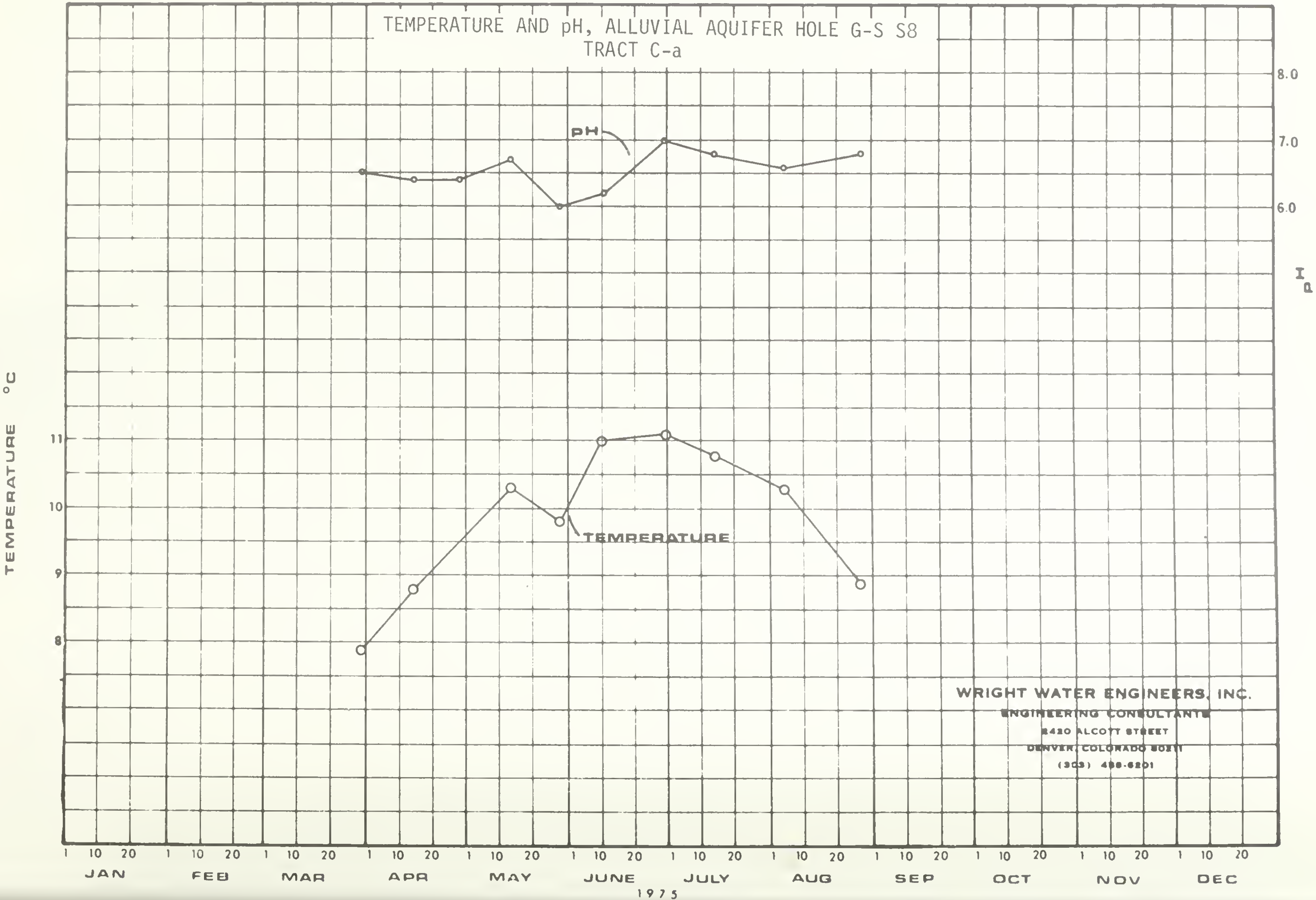
Item	Low	High	Average	No. Items Averaged
Potassium	0.100	2.000	0.656	9
Praseodymi	--	--	0.0	0
Radium	0.100	0.700	0.256	18
Rhenium	--	--	0.0	0
Rhodium	--	--	0.0	0
Rubidium	--	--	0.0	0
Ruthenium	--	--	0.0	0
Samarium	--	--	0.0	0
Scandium	--	--	0.0	0
Selenium	--	--	0.0	0
Silicon	2.000	20.000	8.000	9
Silver	0.000	0.000	0.000	1
Sodium	2.000	99999.000	5.400	5
Strontium	0.100	0.100	0.100	6
Tantalum	--	--	0.0	0
Terbium	--	--	0.0	0
Thallium	--	--	0.0	0
Thorium	--	--	0.0	0
Thulium	--	--	0.0	0
Tin	--	--	0.0	0
Titanium	0.001	0.010	0.004	8
Tungsten	--	--	0.0	0
Uranium	--	--	0.0	0
Vanadium	--	--	0.0	0
Ytterbium	--	--	0.0	0
Yttrium	--	--	0.0	0
Zinc	0.001	0.001	0.001	2
Zirconium	--	--	0.0	0

Figure 1.2-7



WATER DEPTH AND CONDUCTIVITY ALLUVIAL AQUIFER HOLE G-S S8
TRACT C-a

Figure 1.2-8



TEMPERATURE AND pH, ALLUVIAL AQUIFER HOLE G-S S8
TRACT C-a

additional deep aquifer monitor hole was drilled with air on 84 Mesa. The hole will allow monitoring of groundwater quality of the uppermost waterbearing stratum that is considered to contain surface and alluvial water. The hole designated G-S M5, is located in the SW1/4, NW1/4, SW1/4 of Section 8, T1S, R98W. The drilling of G-S M5 was begun on June 26 and was completed at a depth of 907 feet on June 30. The hole was logged on June 30 with electric and density tools and completed to a monitor hole on July 1. Details of the G-S M5 drilling program are presented in section 1.2.4 of RBOSP Progress Report 4 - Interpretive Text. A report by the on site groundwater geologist is presented in RBOSP Progress Report 4 - Interpretive Text Appendix.

The first water was encountered at a depth of about 280 feet. Discharge, measured with a Parshall flume, was approximately three gallons per minute (gpm). From a depth of 309 feet to 311 feet and again from 394 to 396 feet there was a total additional production of about two gpm. The water production then slowly increased to 17 gpm at a depth of 846 feet. The water production held steady to a depth of 895 feet. While drilling from 895 to 907 feet, water production again began to increase. At a depth of 907 feet a connection was attempted to allow further drilling, but circulation with air was never regained. It is estimated that at a depth of about 907 feet the hole was filling with water at the rate of 130 gpm. The result was that the water rose too high in the hole to allow the drill rig air compressors to eject water from the hole and regain circulation. The drilling was halted at 907 feet as the purpose of the hole was to monitor the uppermost aquifer. Figure 1.2-9 is a plot of the water production versus depth.

Conductivity, pH, and temperature were monitored during the drilling of G-S M5. Conductivity of the initial water was 4800 umhos/cm, but it decreased rapidly to 2200 umhos/cm shortly after water was encountered. Conductivity then decreased gradually to 1400 umhos/cm at total depth. The pH remained relatively stable throughout drilling, ranging from 6.8 to 7.0. The temperature ranged from 55°F to 59° F to a depth of about 800 feet. Water production increased at this point, and water temperature dropped to 49°-50°F and remained constant to total depth. Figure 1.2-10 is a plot of conductivity and pH versus hole depth during the drilling of G-S M5. The temperature data were plotted on Figure 1.2-9 with water production. More detailed water quality data are presented in section 1.2.4 of RBOSP Progress Report 4 -Interpretive Text and Interpretive Text Appendix.

G-S M5

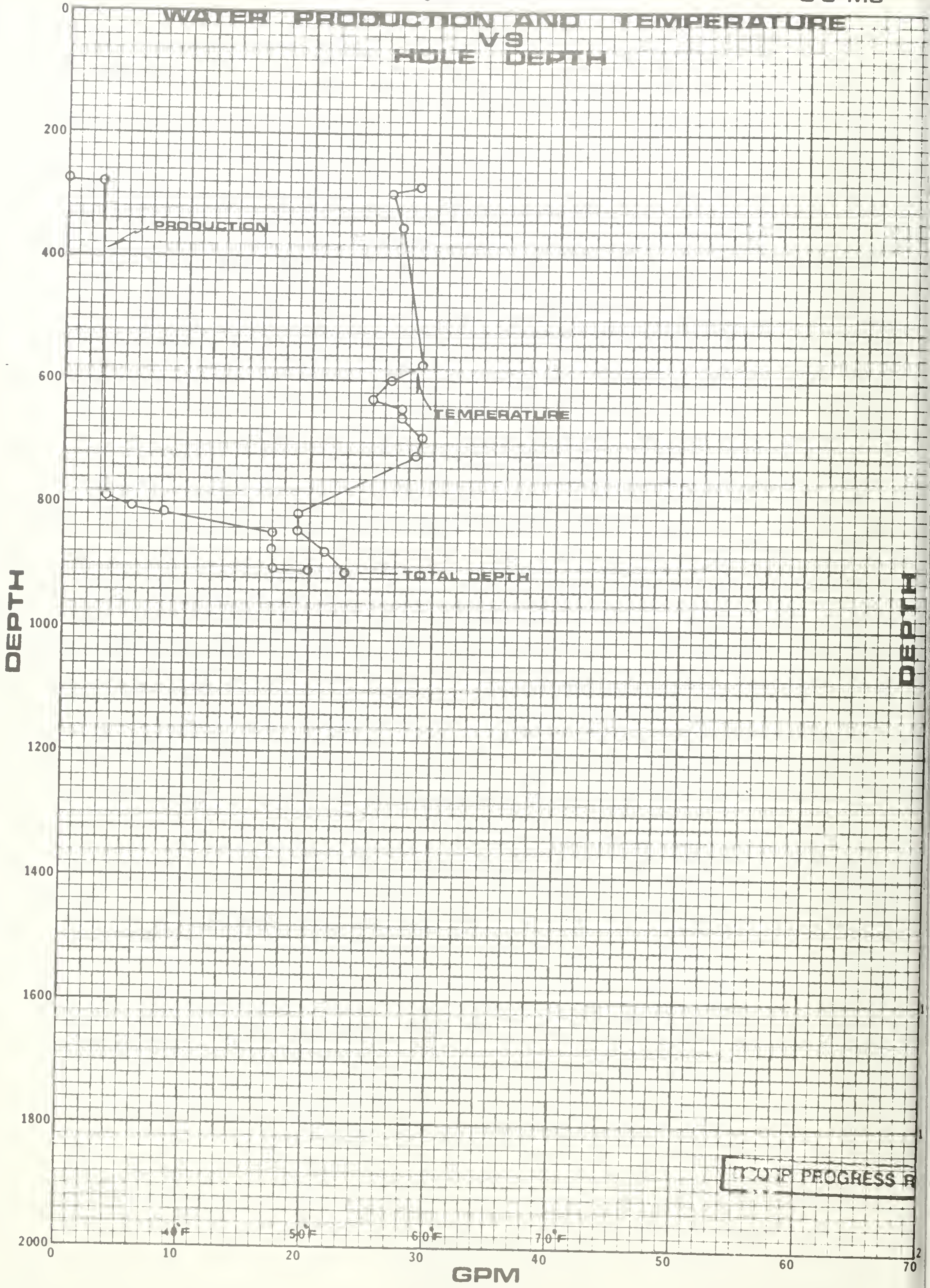
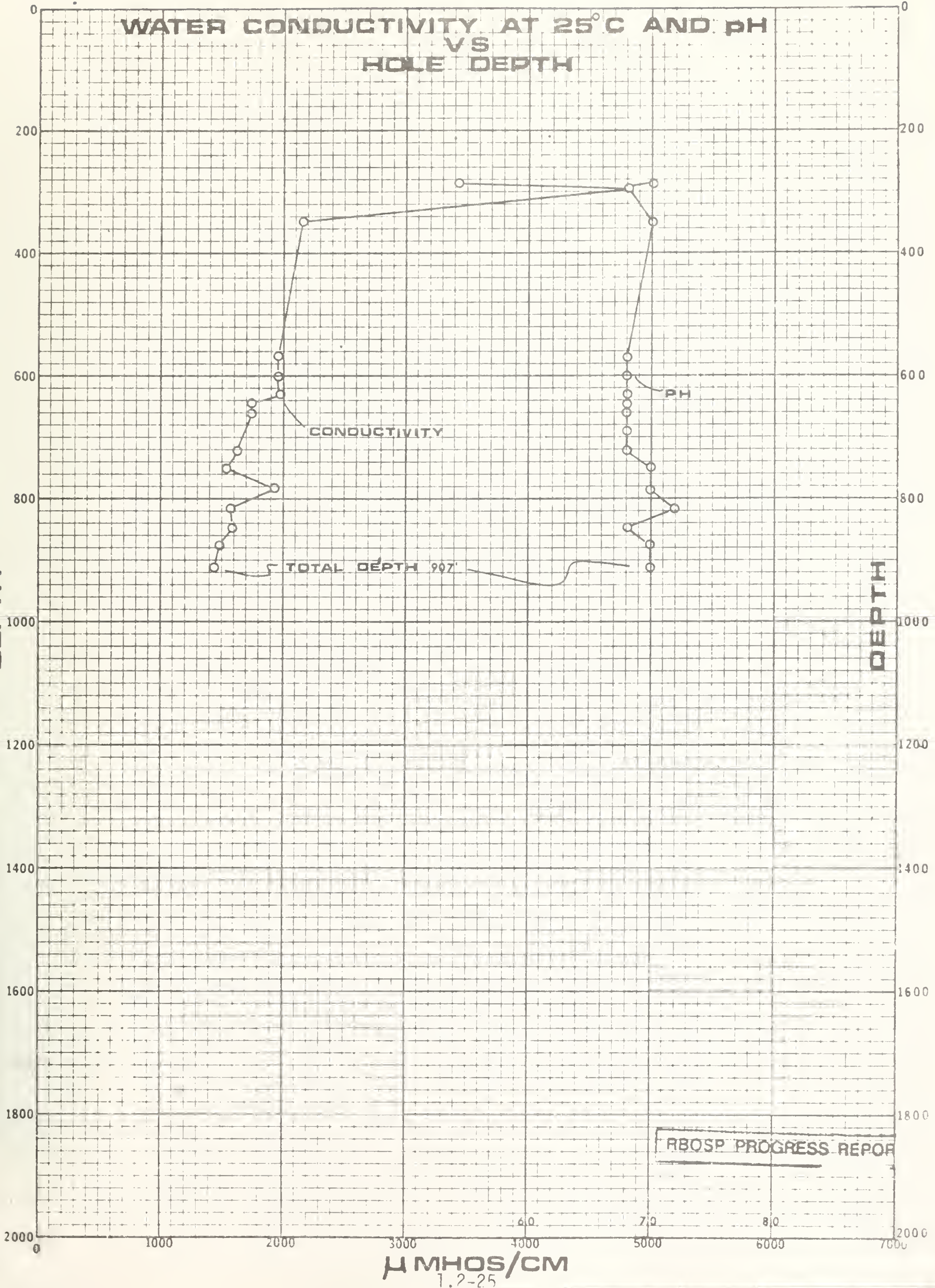

WATER PRODUCTION AND TEMPERATURE
VS
HOLE DEPTH
PRODUCTION
TEMPERATURE
TOTAL DEPTH
DEPTH
0
200
400
600
800
1000
1200
1400
1600
1800
2000
40°F
50°F
60°F
70°F
0
10
20
30
40
50
60
70
GPM
DEPTH
TCUTP PROGRESS R

Figure 1.2-10

GS-M5



Informal pumping tests were not conducted on G-S M5. The very low water production rates encountered in the upper part of the hole did not warrant such testing, and when a significant amount of water was encountered (at 907 feet) the drilling rig was not able to maintain the circulation required for an informal pumping test.

Geophysical logging of G-S M5 was completed on June 30, 1975. An electric log survey and gamma ray-density log survey were run.

1.2.5 Deep Aquifer Completion Program

The completion of the 34 monitor holes was described in detail in section 1.2.5 of RBOSP Progress Report 2. Table 1.2-9 is revised from RBOSP Progress Report 3 to include the new monitor hole G-S M5. Figure 1.2-11 shows the completion configuration for G-S M5. As requested by the Area Oil Shale Supervisor the completion was designed to monitor the first water encountered while drilling G-S M5. The completion was also constructed such that the upper oil shale interval aquifer (far below the first water encountered) could be monitored at a later date with a minimum of time and expenditure. Detailed description of the G-S M5 completion is presented in section 1.2.5 of RBOSP Progress Report 4 - Interpretive Text.

1.2.6 Upper and Lower Aquifer Pumping Tests

The upper and lower aquifer pumping tests were described in detail in section 1.2.6 of RBOSP Progress Report 3. An analysis of the pumping tests is presented in section 1.2.8.6 of RBOSP Progress Report 4 - Interpretive Text. Some of the items investigated include aquifer recharge, barrier conditions and leaky conditions.

1.2.7 Deep Aquifer Monitoring

The monitoring program was initiated in December 1974. At that time only static water levels were measured and recorded. In March 1975, water sampling of the monitor holes was begun. As required each of the deep aquifer monitor holes are to be sampled once a month for six months. The static water level was measured along with the temperature, pH and conductivity as each sample was collected. The sampling program during the month of August completed the six-month monthly sampling program. Ongoing monitoring beginning during the month of September will require that water levels and temperatures be measured monthly; however, water samples are to be collected and analyzed semi-annually as specified.

TABLE 1.2-9

DRILL HOLE COMPLETION SUMMARY
TRACT C-a AND VICINITY

Thirty On-Tract Holes

Drill Hole	Completion	Drill Hole	Completion
G-S 1	U&L	Am 4	P&A
G-S 2-3	U&L	CE - 701	Upper Aquifer Pumping Test
G-S 4-5*	U&L*	CE - 702	U&L
G-S 6	U&L	CE - 703	P&A
G-S 7	P&A	CE - 705-A	Upper Aquifer Pumping Test
G-S 8	Lower Aquifer Only	CE - 707	U&L
G-S 9	U&L	CE - 708	U&L
G-S 10	U&L	CE - 709	U&L
G-S 11	U&L	TO 1	U&L
G-S 12*	U&L*	TO 2	U&L
G-S 13	U&L	TO 3	Upper Aquifer Pumping Test
G-S 14	P&A	G-S D16	Lower Aquifer Pumping Test
G-S 15	U&L	G-S D17	Lower Aquifer Pumping Test
Am 2-A	U&L	G-S D18	Lower Aquifer Pumping Test
Am 3	U&L	G-S D19	Lower Aquifer Pumping Test

Four Off-Tract Holes

Drill Hole	Completion
G-S M1	U&L
G-S M2	U&L
G-S M3	U&L
G-S M4	U&L
G-S M5	AU

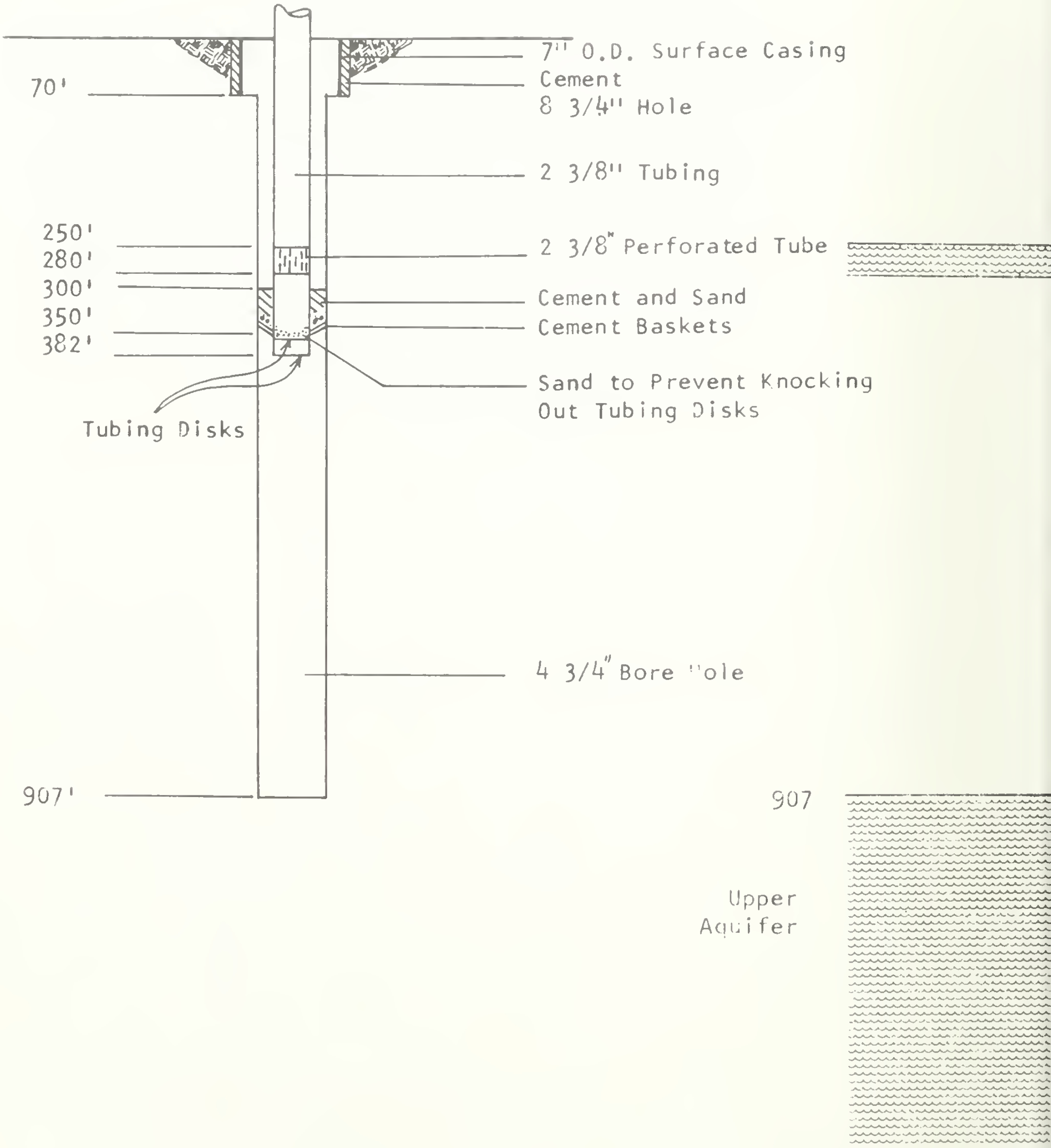
Totals

Completions in Upper and Lower Aquifers	22
Completions in Upper Aquifer Only	3
Completions in Lower Aquifer Only	5
Completions in Uinta Fm. Aquifers	1
Holes Plugged and Abandoned	4
Total Number of Holes	35

Am = Amoco Production Company
CE = Cameron Engineers, Inc.
G-S = Gulf-Standard (Indiana)
TO = The Oil Shale Corporation
U&L = Upper and Lower Aquifer Completions
P&A = Plugged and Abandoned
AU = Aquifers, Uinta Fm.

*Holes Temporarily Modified for Upper Aquifer Pumping Test

G-S M5 HOLE COMPLETION DIAGRAM



VERTICAL SCALE 1" – 200'
HORIZONTAL SCALE 1" – 1'0"

RIO BLANCO
OIL SHALE PROJECT

HOLE G-S M5 DEPTH 907
JULY, 1975

WRIGHT WATER ENGINEERS, INC
ENGINEERING CONSULTANTS
2420 ALCOTT STREET
DENVER COLORADO 80211

Computer printouts of water quality data for samples collected during the deep aquifer monitoring program are presented in RBOSP Progress Report 4 - Raw Data. Table 1.2-10 is a summary of the wet chemical analysis of the water samples. Table 1.2.-11 is a summary of the spectographic analysis of the deep aquifer monitoring samples. Water quality data in the Raw Data submission of this report for deep aquifer monitoring are listed under Method 3 or Method 3A. The differentiation is made in order to separate those samples analyses which vary significantly from the sample norm due to sampling technique. Method 3A contains the sample analyses which vary from what is considered normal. Figure 1.2-12 is a map showing the location of each of the monitoring holes.

1.2.8 Hydrologic Program Summary and Analysis

Section 1.2.8 of the previous RBOSP Progress Reports 2 and 3, Raw Data Input to Mathematical Model has been redesignated Hydrologic Program Summary and Analysis. RBOSP Progress Report 4 - Interpretive Text presents a summary and analysis of the Hydrologic Program. Section 1.2.8 of Progress Report 4 - Interpretive Text has been divided into subsections wherein each task of the Hydrologic Program is summarized and some subsections are analyzed.

Study of the Piceance Creek Basin indicates that there are only four perennial streams and tributaries within the drainage basin: Piceance Creek, Dry Fork of Piceance Creek, Black Sulphur Creek, and Yellow Creek. Yellow Creek is only perennial along a few miles above its confluence with the White River. The majority of the surface drainages in the Piceance Creek Basin are intermittent in that they flow only during spring snowmelt or during periods of rapid runoff caused by heavy thunder showers. Some of the intermittent streams do flow continuously along certain reaches. As expected the alluvial aquifers along the perennial streams are saturated. The degree of saturation of alluvium along intermittent streams is highly variable and subject to seasonal change. The alluvium of some of the smaller drainages remained dry (unsaturated) even during the snowmelt runoff period when the highest water table levels were recorded in the alluvium of the major surface drainages.

The Hydrologic data generated during the corehole drilling programs prior to and after leasing of Tract C-a and the deep aquifer drilling program indicated the presence of two deep aquifers in the oil shale strata underlying the Tract C-a area. Section 1.2 of RBOSP Progress Report 2 describes these

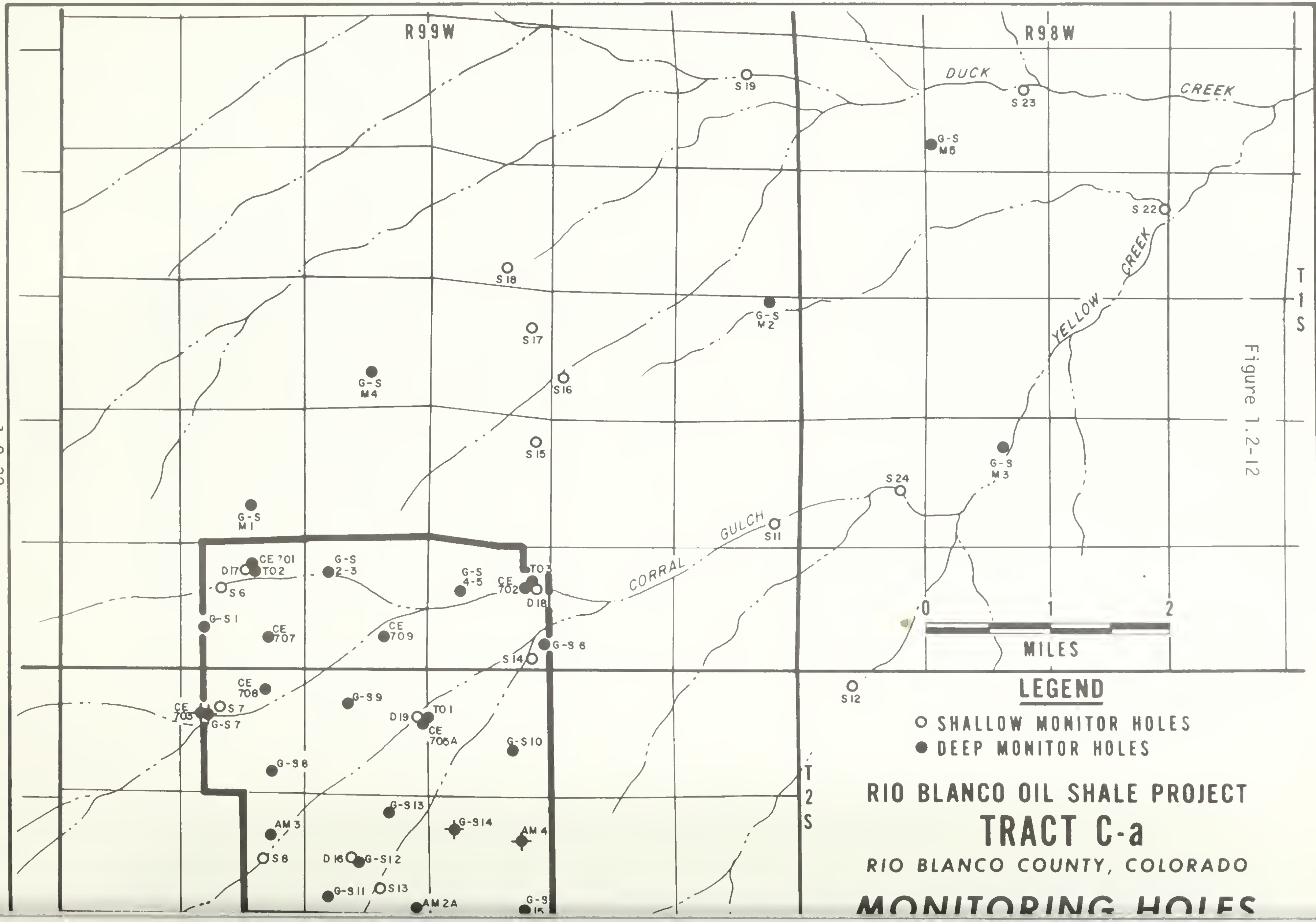
Table 1.2-10
SUMMARY WET CHEMICAL ANALYSES
DEEP AQUIFER MONITORING SAMPLES
TRACT C-a AND VICINITY

	Lower Aquifer				Upper Aquifer				Combined Aquifer			
Item	Low	High	Average	No. Items Avg.	Low	High	Average	No. Items Avg.	Low	High	Average	No. Items Avg.
Aluminum	-0.100	1.600	0.120	45	-0.100	2.200	0.176	46	-0.100	0.100	0.005	21
Ammonia	-0.100	5.600	0.558	128	-0.100	10.600	0.647	144	-0.100	3.000	0.974	28
Arsenic	-0.050	0.050	0.001	148	-0.050	0.200	0.004	155	-0.100	0.500	0.038	30
Bicarbonate	-0.100	11800.000	1082.208	163	-0.100	2760.000	607.246	183	350.000	19600.000	2073.000	58
Cadmium	-0.010	0.030	0.001	149	-0.010	0.100	0.002	139	-0.010	0.070	0.009	24
Calcium	-1.000	515.000	42.120	163	0.800	780.000	69.279	183	0.100	88.000	26.290	58
Carbonate	-1.000	3160.000	98.498	163	-0.100	1190.000	36.312	182	-0.100	3000.000	163.982	57
Chloride	-1.000	205.000	35.704	163	-1.000	240.000	26.287	183	3.000	6600.000	238.352	58
Chromium	-0.050	0.010	0.000	144	-0.050	0.500	0.006	140	-0.050	0.570	0.057	24
Copper	-0.100	0.300	0.018	149	-0.100	0.800	0.028	139	-0.100	0.100	0.004	24
Fluoride	-0.050	120.000	13.547	164	0.060	80.000	4.299	183	0.200	60.000	12.869	58
Hydroxide	-0.100	890.000	221.250	8	-0.100	380.000	9.268	41	-0.100	-0.100	0.0	30
Iron	-0.050	33.000	2.763	163	-0.050	13.000	3.231	167	-0.050	16.000	0.685	51
Lead	-0.100	26.000	0.636	149	-0.050	3.800	0.320	139	-0.050	0.500	0.065	24
Magnesium	-1.000	140.000	37.986	163	-0.100	150.000	50.781	182	0.700	96.000	27.265	57
Mercury	-0.010	0.002	0.000	145	-0.010	0.045	0.000	142	-0.010	-0.010	0.0	16
Nitrate	-0.100	55.000	0.810	163	-0.100	7.000	0.514	183	-0.100	15.000	1.152	58
Phosphate	-0.100	2.400	0.043	150	-0.100	9.200	0.209	142	-0.100	8.200	2.425	24
Potassium	-1.000	84.000	26.800	5	-1.000	93.000	12.773	41	-1.000	76.000	15.167	30
Selenium	-0.010	-0.001	0.0	149	-0.100	0.010	0.000	156	-0.100	0.010	0.000	30
Silicon Dioxide	-0.100	50.000	11.772	163	-0.100	58.000	25.322	183	6.400	41.000	17.790	58
Sodium	86.000	5290.000	534.024	163	40.000	1170.000	273.000	183	165.000	12000.000	1007.276	58
Sulfate	-10.000	740.000	229.021	163	-4.000	900.000	331.404	183	-4.000	535.000	180.534	58
Sulfide	-0.010	2.400	1.467	3	-1.000	4.100	1.556	18	-1.000	12.000	2.753	19
Zinc	-0.500	68.000	1.387	149	- .500	15.000	0.687	130	-0.500	1.000	0.286	14
Gross Alpha	0.100	86.000	6.452	111	0.200	29.000	4.248	95	0.500	12.000	6.675	8
Gross Beta	3.000	830.000	67.290	31	4.000	73.000	16.917	12	1.000	57.000	26.229	7
Hardness	20.000	1260.000	258.632	163	16.000	1870.000	380.929	183	30.000	520.000	175.000	57
pH	6.000	73.000	7.760	163	6.000	10.200	7.074	183	6.800	8.800	7.904	57
Conductance	760.000	15800.000	2308.627	161	675.000	6200.000	1529.428	182	880.000	28000.000	3426.754	57
Diss. Solids	430.000	12200.000	1589.383	162	425.000	3140.000	1150.743	183	650.000	30700.000	2869.509	57
Manganese	-0.050	0.500	0.057	157	-0.100	0.780	0.114	155	-0.200	0.320	0.018	40
Alkalinity	-0.100	10480.000	929.086	158	-0.100	2360.000	515.561	141	31.000	9310.000	1069.629	27
Cyanide	-0.100	0.030	0.000	143	-0.010	-0.010	0.0	114	---	---	0.0	0
Boron	-0.100	25.000	1.758	146	-0.100	4,800	0.679	125	-0.100	1.500	0.620	10
Barium	-1.000	-0.100	0.0	144	-1.000	-0.100	0.0	115	---	---	0.0	0
Silver	-0.010	0.110	0.004	144	-0.100	0.100	0.008	115	---	---	0.0	0
Nickel	-0.100	0.100	0.022	142	-0.010	0.200	0.026	115	---	---	0.0	0
Lithium	---	---	0.0	0	-0.500	-0.500	0.0	2	---	---	0.0	0
TOC	1.000	37.000	8.849	73	-1.000	34.000	7.884	69	---	---	0.0	0

Table 1.2-11
SUMMARY SPECTOGRAPHIC ANALYSIS DEEP AQUIFER MONITORING SAMPLES TRACT C-a AND VICINITY

	Lower Aquifer				Upper Aquifer				Combined Aquifer			
Item	Low	High	Average	No. Items Avg.	Low	High	Average	No. Items Avg.	Low	High	Average	No. Items Avg.
Aluminum	0.001	5.000	0.211	6	0.001	1.000	0.172	114	0.010	1.000	0.182	50
Antimony	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Arsenic	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Barium	0.001	0.100	0.043	10	0.001	0.050	0.015	6	0.100	0 100	0.100	1
Berylium	--	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Bismuth	---	---	0.0	0	---	---	0.0	0	0.100	0.100	0.100	1
Boron	0.050	99999.000	0.475	86	-0.020	5.000	0.322	114	0.050	5.000	0.456	53
Cadmium	99999.000	99999.000	0.0	0	99999.000	99999.000	0.0	0	---	---	0.0	0
Calcium	5.000	99999.000	8.929	14	1.000	99999.000	5.500	4	2.000	99999.000	5.500	4
Cerium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Cesium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Chromium	0.001	0.010	0.005	2	0.000	0.050	0.010	13	0.001	0.050	0.012	13
Cobolt	---	---	0.0	0	0.001	0.001	0.001	1	---	---	0.0	0
Columbium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Copper	0.001	0.100	0.009	70	0.000	0.050	0.010	79	0.000	0.050	0.006	30
Oysprosium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Erbium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Europium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Gadolinium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Gallium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Germanium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Gold	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Hafnium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Holmium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Indium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Iridium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Iron	0.005	5.000	0.207	87	0.010	1.000	0.119	112	0.010	10.000	0.518	50
Lanthanum	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Lead	0.001	0.500	0.057	16	0.001	0.500	0.056	27	0.005	0.500	0.129	9
Lithium	0.001	5.000	0.121	54	-0.500	0.500	0.052	65	-0.500	1.000	0.153	36
Lutetium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Magnesium	2.000	99999.000	5.538	13	2.000	99999.000	7.000	6	1.000	99999.000	6.750	12
Manganese	0.001	0.200	0.031	62	0.001	1.000	0.057	69	0.010	10.000	0.520	22
Mercury	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Molybdenum	0.001	0.100	0.009	45	0.001	0.500	0.025	57	0.001	0.061	0.012	28
Neodymium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Nickel	---	---	0.0	0	0.001	0.010	0.007	3	---	---	0.0	0
Osmium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Palladium	---	---	0.0	0	0.100	0.100	0.100	1	---	---	0.0	0
Platinus	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Potassium	0.010	99999.000	1.911	81	0.050	99999.000	1.432	97	0.100	99999.000	1.538	42
Praseodymium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Radium	0.100	2.100	0.476	21	0.100	0.800	0.215	20	0.300	0.500	0.400	3
Rhenium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Rhodium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Rubidium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Ruthenium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Samarium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Scandium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Selenium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Silicon	-0.500	99999.000	7.576	85	2.000	50.000	14.132	114	5.000	99999.000	16.245	53
Silver	0.000	0.001	0.001	10	-0.001	0.001	0.000	14	0.000	0.000	0.000	3
Sodium	0.100	99999.000	7.065	17	2.000	99999.000	8.133	15	99999.000	99999.000	0.0	0
Strontium	0.010	99999.000	0.147	75	0.001	1.000	0.177	82	0.100	0.500	0.185	34
Tantalum	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Terbium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Thallium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Thorium	1.000	1.000	1.000	1	---	---	0.0	0	---	---	0.0	0
Thulium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Tin	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Titanium	0.001	0.050	0.006	37	0.001	0.150	0.017	58	0.001	0.200	0.020	38
Tungsten	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Uranium	-1.500	-1.500	0.0	2	---	---	0.0	0	---	---	0.0	0
Vanadium	---	---	0.0	0	0.001	0.100	0.027	16	0.001	0.050	0.019	19
Ytterbium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Yttrium	---	---	0.0	0	---	---	0.0	0	---	---	0.0	0
Zinc	0.001	0.500	0.087	15	0.001	0.500	0.055	23	0.005	0.100	0.041	4
Zirconium	---	0.0	0	0	---	---	0.0	0	---	---	0.0	0

Figure 1.2-12



RIO BLANCO OIL SHALE PROJECT

TRACT C-a

RIO BLANCO COUNTY, COLORADO

MONITORING HOLES

two aquifers in detail. Prior to October 1974, all of the 13 prelease drill and coreholes had been left open at the request of the USGS. Leaving the holes open allowed the waters of the the two aquifers to intermingle. The upper aquifer generally has a higher hydrostatic head than the lower aquifer which results in a flow from the upper aquifer to the lower aquifer. The exception to this is in the extreme northeast corner of Tract C-a where the hydrostatic heads are reversed. During the time in which the holes were left open it has been estimated that as much as 15,000 acre-feet of water flowed from the upper aquifer to the lower aquifer. By comparison only 175 acre-feet of water was produced during the pumping tests on Tract C-a. All open holes on or near Tract C-a have now been completed in a manner such that the two aquifers are effectively separated.

A description of eight pumping tests conducted on Tract C-a was reported in section 1.2.6 of RBOSP Progress Report 3. Data acquired from the pumping tests indicates that flow within the aquifers during pumping was radial with linear tendencies. The linear tendencies probably reflect directions or linear trends of joint and fracture systems. Figures 1.2-41 through 1.2-56 presented in section 1.2.6 of RBOSP Progress Report 4 - Interpretive Text are maps of water level changes at different periods of time for the eight pump tests. The maps show the cone of depression, favored direction of flow and boundary conditions that existed at various times during the pumping tests.

A review of the maps showing the upper aquifer cones of depressions resulting from the upper aquifer pumping tests indicates that the structural geology of the area (faults and perhaps joint and fracture systems) affects the favored direction of flow because the barriers in the upper aquifer appear linear.

The Jacob's Plots of the response to the upper aquifer pumping tests show that the draw down curve begins to flatten out after a period of pumping the upper aquifer. This indicates a leaky condition in the upper aquifer. The Jacob's Plots were presented to the Area Oil Shale Supervisor in section 1.2 of RBOSP Progress Report 3 - Interpretive Text Appendix.

Maps showing the cones of depression from the lower aquifer pump tests indicate that some anisotropic conditions exist in the lower aquifer. The cones of depression for the G-S D16 pumping test indicate that permeability in the lower aquifer increases toward the northwest corner of Tract C-a. The cones of depression for G-S D17 again relfected the increase in permeability of the lower aquifer in the northwest corner of

Tract C-a. The cones of depression for G-S D19 were generally symmetrical with the exceptions being a rapid lowering of the water level between G-S 8 and G-S D19 and a steepening of grade in the slope of the cone of depression in the vicinity of the northeast corner of Tract C-a.

Reduction of the data from pumping tests at G-S D19 and G-S D18 indicates a hydrologic connection between the upper and lower aquifers in the northeast corner of Tract C-a. This can be seen by correlating upper aquifer water level response to the lower aquifer pumping tests at G-S D18 and G-S D19. A review of the upper aquifer water quality also indicates that the lower aquifer water of poorer quality is mixing with the upper aquifer water, thus resulting in a lower water quality for the upper aquifer in the northeast corner of Tract C-a in comparison with the water quality in the upper aquifer over the rest of the tract.

Section 1.2.8 of RBOSP Progress Report 4 - Interpretive Text contains figures numbered 1.2-58 to 1.2-62 which are areal plots of thickness, transmissivities, and permeabilities for both the upper and lower aquifers.

Data from the deep aquifer monitoring program basically defines two parameters; water level and water quality. Collection of valid data from the monitoring of water levels in the upper and lower aquifers was initiated in December of 1974. Water levels measured prior to that time were affected by commingling of the water and hydrostatic heads of the two aquifers. Only after the aquifers had been isolated through a comprehensive hole completion program could piezometric (water level) data be collected. Water quality monitoring was initiated in March of 1975; however, water samples were collected and analyzed during the various drilling programs and represent valuable long term water quality data.

The effect of isolating the aquifers (allowing the aquifers to return to their natural state) was that the water level in the upper aquifer rose as much as 30 feet and the water level in the lower aquifer dropped as much as 25 feet from the period of January to August 1975. This effect is reversed in the extreme northeast corner of tract where the hydrostatic heads of the two aquifers are known to be reversed. This rising and lowering of hydrostatic heads for the upper and lower aquifers respectively has decelerated.

Section 1.2.8 of RBOSP Progress Report 4 - Interpretive Text contains figures numbered 1.2-72 through 1.2-108 which are contours of selected chemical constituents on an areal basis for the upper and lower aquifers. Those figures were generated from computer calculated and plotted water quality data obtained during the monitoring program. From these figures it can be seen that the best water quality in the upper aquifer is located along the western boundary of Tract C-a and in a relatively large area surrounding corehole CE-705A. The poorest water quality in the upper aquifer is located in the extreme northeast corner of Tract C-a. The best water quality in the lower aquifer is also found along the western boundary of Tract C-a and the poorest water quality in the extreme northeast corner of the tract.

Figures 1.2-94 and 1.2-95 in section 1.2.8 of RBOSP Progress Report 4 - Interpretive Text show extremely high values of iron for both the upper and lower aquifers. The high iron values range from one to more than 12 parts per million. It is thought that these high iron values are the result of a reaction between the aquifer waters and the steel casing in the drill and coreholes. This reasoning is based on the facts that generally older holes have the highest iron concentrations and the iron concentration in a majority of the holes is increasing with respect to time.

ABSTRACT

The environmental baseline studies for Tract C-a Oil Shale Lease are multidisciplinary and include air quality and meteorology, terrestrial ecosystem, aquatic ecosystem, soils survey and classification, archaeology, revegetation, toxicology, trace metals, seismiticity and visibility studies.

The above studies were initiated in October 1974 and on-going progress has been reported on a quarterly basis. The time period covered by this report is June through August 1975.

A total of 56 air quality and meteorology parameters is being measured at four locations in the vicinity of Tract C-a.

Analysis of data collected to date indicates that most air quality parameters fall within the expected low background ranges. Exceptions are particulates, ozone and hydrocarbons. Federal and state standards for particulates were exceeded three times during the quarter. The State Standard for SO_2 was exceeded 258 times (which represents about 12% of the total summer measurement period) and non-methane hydrocarbon levels exceeded federal standards 26 times.

Meteorological measurements include lower air studies, upper air studies, evaporation rate, snow depth and water content, and visibility.

During the summer, winds at two sites were predominantly from the southeast, from the west at a third site, and from the south-southwest at a fourth site. Mean wind speeds varied from 6 to 9 miles per hour at the four locations. Wind speeds during the day were on the average 4 to 7 miles per hour higher than at night.

Although there is a substantial difference in the daily variation, temperatures flucuated a great deal between sites during the day. The average temperatures over each month and the season agreed to within 1.4 C between sites.

Atmospheric stability was determined from temperature differences between the 10- and 60-m levels. When the break-up of the mean surface inversion occurs, atmospheric stability becomes significantly unstable. The intensities of the most stable inversions were about the same as those of the most unstable conditions.

Relative humidity decreased rapidly at sunrise (from 35 to 23%) as surface heating occurred.

Results of upper air studies indicate that the atmospheric profile from the surface to 1,000 feet is extremely complex, with inversions in the morning which break up early in the day. Temperature inversions were quite pronounced in the valleys below the tract.

The terrestrial baseline program involves vegetation, small mammal, large mammal, predator, bird, reptile, amphibian and invertebrate studies. A variety of sampling techniques in a widely-spaced area is used to collect these data.

An inventory of plants in the area revealed the presence of 242 species. One species observed (a milkvetch) has been listed by the Smithsonian Institute as threatened. Ten major vegetation types have been identified. The most widely distributed plant type is sagebrush.

Twelve species of small mammals were captured during the quarter. The largest number of small mammals was captured in sagebrush habitat. The most common small mammals trapped were the deer mouse and the least chipmunk.

The cottontail rabbit, white-tailed jack rabbit, the porcupine and three species of bats were also encountered during the quarter. Since these studies were initiated in October 1974, 33 species of mammals have been documented in the area. Mule deer and elk were not observed on tract during the June-August quarter. However, feral horses and domestic livestock were observed. At least five species of mammalian predators occur in the area. They are the coyote, weasel, ermine, bobcat and badger.

Forty-two additional species of avifauna were recorded during the quarter, bringing the number of species identified to date to 127. Three species of special interest have been seen in the area, including the Greater Sandhill Crane, Prairie Falcon and Peregrine Falcon. One Sandhill Crane was seen at the confluence of Piceance Creek and the White River (off study area). Sandhill Crane sightings were also reported in April 1975.

Five species of reptiles were observed during the quarter.

Eighteen taxa of invertebrates were also collected and identified by seven different methods of sampling. Sagebrush appears to harbor the largest number of invertebrates per unit area of plants.

Thirty-five sampling stations were chosen to represent the broadest possible range of aquatic habitats available. In order to characterize the aquatic habitats of the permanently flowing streams, a total of 18 sampling stations was located on the White River and lower Yellow Creek. The aquatic sampling began in October 1974 and will continue through August 1976. Samples are collected 6 times per year, with the most intense sampling frequency occurring during the warmer months when biological activity is greatest.

This progress report contains data from samples taken during April, May-June, and July-August 1975. Samples were taken at 27 sites, 28 sites and 30 sites during April, May-June and July-August, respectively.

During the May-June period, the concentrations of sulfate, turbidity and dissolved solids and the specific conductance in the White River were somewhat lower than observed during previous periods. The lower levels of these constituents may be attributed to dilution resulting from the high flows which occurred during the period.

During April and May-June, the total number of phytoplankton taxa observed was 129 and 121, respectively. Also during April and the May-June period, totals of 58 and 76 zooplankton taxa were observed. The periphyton collected during April contained 71 algae taxa, whereas the May-June collections contained 89 taxa. The periphyton was generally dominated by the diatoms.

During April, a total of 118 benthic taxa was encountered, whereas the May-June collection contained 92 taxa. Aquatic macrophytes were observed at 6 sampling sites during May-June. During the May-June sampling, eight fish species were encountered. The catch was dominated by rough and forage fishes including dace, flannelmouth sucker, fathead minnow, and bluehead sucker. A single game fish (cutthroat trout) was observed during May-June. The high volume and velocity of flow in the White River generally hampered fishing efforts during May-June.

Preliminary soil surveying and mapping was completed for the area during the quarter. Twelve soil types were identified and mapped. Trace element and mechanical analysis are currently being conducted by the Soil Conservation Service. Additional soils studies will be conducted to determine soil/plant relationships and trace metal concentrations.

An archaeological survey in the area was completed during the quarter. Artifacts transported into the area by man were found at 196 locations. They included toolstone flakes, deposits of large numbers of tools, broken and discarded tools and evidences of human tool making.

A revegetation program was formulated and initiated during the quarter. Considerations addressed were the shape, depth, texture and composition of spent shale disposal piles, selection of species for revegetation, location, number and layout of experimental test plots, seedbed preparation, mulching, fertilization, sowing rates, plant response parameters and analysis of data.

A 3-year revegetation program has been planned. Additional experiments will be planned and initiated as data become available.

2.0 ENVIRONMENTAL BASELINE DATA GATHERING PROJECT

The five-phase baseline environmental program currently under way on Tract C-a is outlined in Figure 2-1. These programs are designed to meet all lease stipulations and to gather sufficient information to accurately describe the existing components of the environment.

The data gathered through these programs will be used to assess the effects of the oil shale development on the environment, to develop sound management and mitigation plans consistent with the proposed development and to design monitoring programs which will insure early detection and proper mitigation of any adverse effects of mining operations and associated activities on the environment.

Data collected as a result of these studies are reported on a quarterly basis. Collection of data for most programs began in October 1974. The period covered in this report is from June through August 1975. In some instances, data collected during earlier periods may be summarized and discussed in order to provide a more comprehensive analysis. However, since data collected to date represent less than 1 full year of data, all interpretations are made with recognized qualifications.

Objectives and methods of these programs were discussed in Progress Reports 2 and 3, and are not included unless some change in these procedures has occurred. In such cases, the objectives or methods used for data being reported will be explained.

A description of the tract and identification of contractors involved in these studies appears in Progress Report 2.

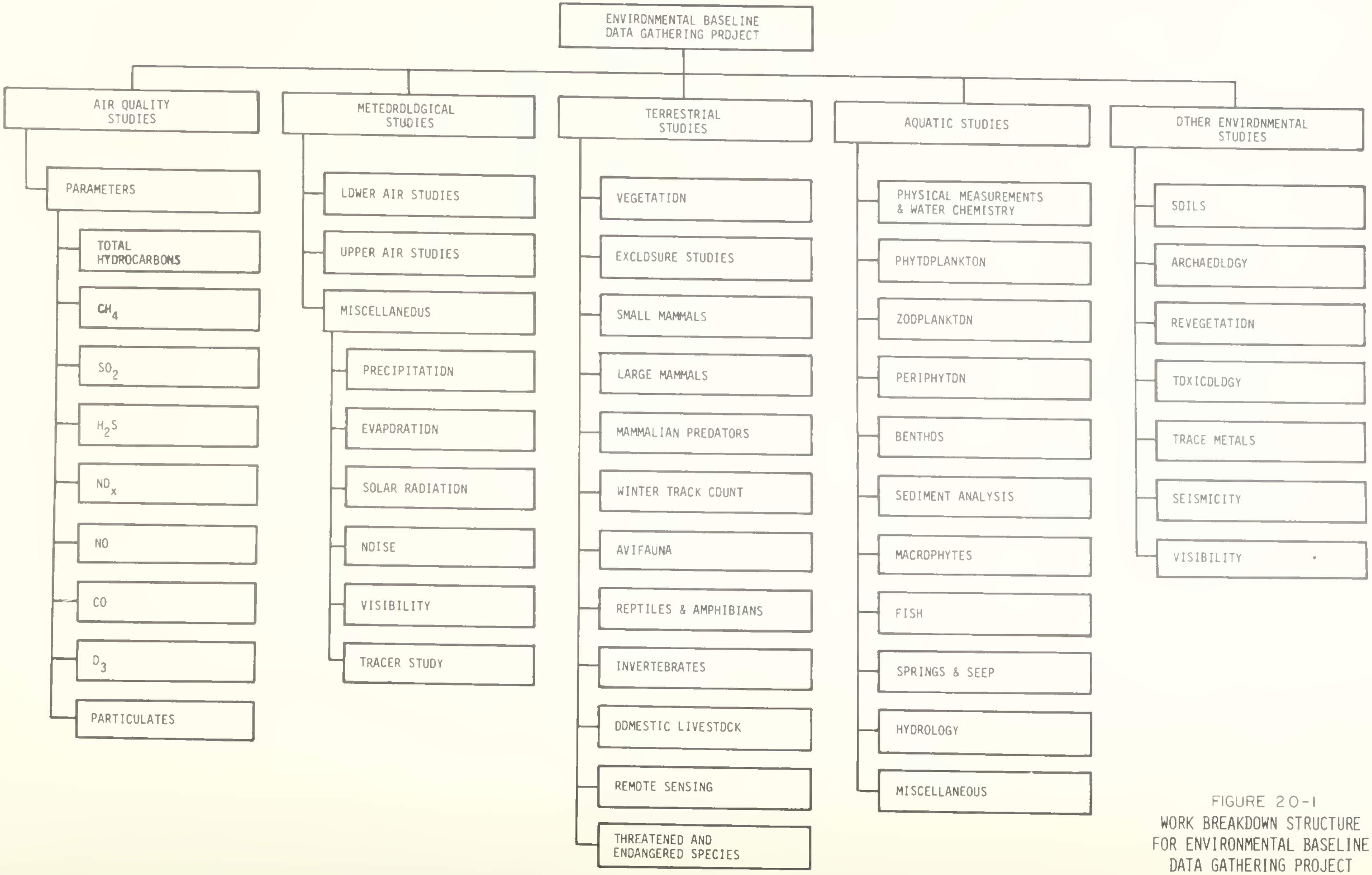


FIGURE 20-1
WORK BREAKDOWN STRUCTURE
FOR ENVIRONMENTAL BASELINE
DATA GATHERING PROJECT

2.1 Air Quality

Air quality studies are designed to meet and, in some cases exceed, lease stipulations.

The Air Quality and Meteorological Data Acquisition System for the RBOSP consists of: four monitoring sites, each with tower-mounted meteoroglogical instruments and trailer-contained air quality instrumentation; interface electronics; RF data telemetry links; and a central minicomputer for data storage and processing (Figure 2.1-1). The parameters measured at each site are as follows:

Site No.	THC	CH_4	SO_2	H_2S	NO_x	NO	CO	O_3	Particulates
1	X	X	X	X	X	X	X	X	X
2	X	X	X	X					X
3	X	X	X	X	X	X	X	X	X
4	X	X	X	X					X

Data from all stations are sent to the minicomputer at the central station (Site 1). The minicomputer exponentially averages the air quality data from the continuously operating analyzers. The minicomputer stores the data on magnetic tape, the primary recording medium. A high speed printer provides a hardcopy printout. Backup analog recorders are located in air quality trailers.

2.1.1 Parameters

2.1.1.1 Objectives

Air quality parameters are the same as those described in Progress Report 3. See Section 2.1.1.1 for specific objectives.

2.1.1.2 Methods

Table 2.1-1 lists the instruments and air quality measurement techniques used for monitoring gases. Also presented are the lower detectable limits (LDL) for the instruments. The LDL are interpreted as the lowest concentration that can be differentiated from noise irrespective of sampling time.

Detection techniques are the same as those described in Progress Report 3. See Section 2.1.1.2 for specific methods used in the Air Quality Studies.

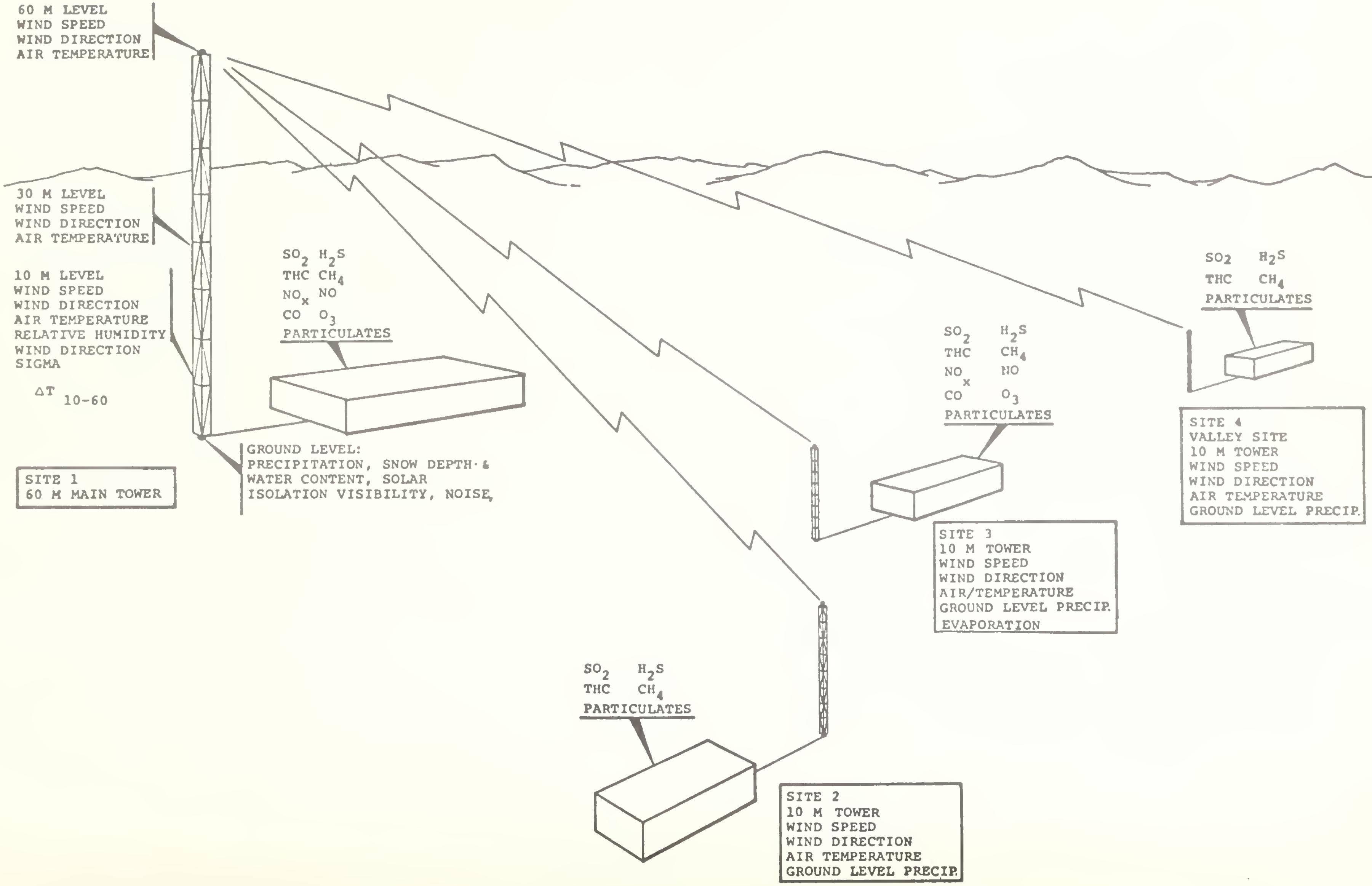


Figure 2.1-1. Meteorological and air quality data acquisition system for Tract C-a, RBOSP.

Table 2.1-1. Air quality instrumentation and measurement techniques, RBOSP.

Parameter	Manufacturer	Model	Technique	Lower Detectable Limit (ppm)	Accuracy ± (ppm)
SO_2/H_2S	Bendix	8700X	Flame photometric with separation column for SO_2 and H_2S	0.005	0.020
NO_x/NO	Bendix	8101-B	Chemiluminescence	0.005	0.010
THC/CH_4	Bendix	8201	Flame ionization detector with separation column for CH_4	0.005	0.10 (THC) 0.02 (CH_4)
Photochemical Oxidant (O_3)[1]	Bendix	8002	Chemiluminescence	0.001	0.004[2]
CO	Bendix	8501-5CA	Nondispersive infrared detector	0.5	0.500[2]

---

[1] Photochemical oxidant corrected for interference due to nitrogen oxide and nitrogen dioxide as measured by the Federal Reference as ozone (O_3) with the chemiluminescence method.

[2] Estimated accuracy.

2.1.1.3 Results

Analysis of the air quality parameters measured on Tract C-a indicates that with the exception of particulates, ozone, and hydrocarbons, the mean values are in the expected low background ranges. Results of the analysis are discussed and tabulated in this section.

Table 2.1-2 presents a comparison of Federal and State Standards with measurements taken from 1 June 1975 through 31 August 1975 at the RBOSP sites. Nonmethane hydrocarbon (NMHC), ozone, sulfur dioxide (SO_2), and particulates exceeded standards. The number of times that these measurements exceeded standards was analyzed, taking into consideration Table 2.1-1, which presents the lower limits of detectability and the accuracies of the analyzers used. When the lower limit of detectability of an analyzer is of similar magnitude as the regulatory standard, as is the case with SO_2 and the State 24-hour SO_2 maximum, the analyzer will, at times, indicate higher values than that maximum, although the standard may not be violated. This apparent discrepancy results from the fact that the absolute measurement must be considered to have the lower limit of detectability plus or minus the accuracy of the analyzer. In the case of SO_2, this uncertainty combination of LDL and analyzer accuracy is 0.005 ± 0.020 ppm. Therefore, if an actual ambient concentration of 0.005 ppm SO_2 were present then the analyzer could theoretically read in a range of -0.015 ppm to 0.025 ppm.

The number of times the State SO_2 Standard is exceeded, as described above, could possibly be related to instrument specifications. That is, the combination of detection limit and accuracy is comparable in magnitude to the standards value. The same reasoning follows for ozone and NMHC and associated standards.

The Federal 24-hour maximum, secondary standard and the State 24-hour maximum standard to particulates were violated three times. However, the means for all sites for the quarter if continued at the same rate would not result in an annual mean higher than the Federal annual particulates standard.

The 24-hour maximum SO_2 State standard of 0.005 (ppm) was exceeded 258 times. This was calculated by using a sliding window technique for all consecutive 24-hour periods. The first 24-hour set of data for the season was averaged and checked against the State 0.005 ppm standard. This technique continued with the 2 to 25 hours, 3 to 26 hours, etc., periods, totalizing the number of times 0.005 was exceeded. Out of a total of 2184 possible 24-hour periods, 258 were exceeded. This is about 12% of the time during the summer season that this State standard was exceeded.

Table 2.1-2. Comparison of Federal and State air quality standards to measurements made during Summer 1975, RBOSP.

	Standard				No. of Times Exceeded During Quarter	Site 1 Max. Measured			Site 2 Max. Measured			Site 3 Max. Measured			Site 4 Max. Measured		
						Value			Value			Value			Value		
Parameter	μg/m³	(ppm)	Time Interval	Type of Standard		μg/m³	ppm	Time	μg/m³	ppm	Time	μg/m³	ppm	Time	μg/m³	ppm	Tim
CO	10,000	(35)	1 hr max.	Primary and Secondary[1/]	0	3806	3.241	0700 7/18	——	——	——	3021	2.532	0100 8/1	——	——	——
CO	35,000	(9)	8 hr max.	Primary and Secondary[1/]	0	3626	3.085	0800 7/18	——	——	——	1417	1.208	2200 8/15	——	——	——
Nonmethane Hydrocarbon	160	(0.24)	3 hr max. (6-9 am only)	Primary and Secondary[1/]	26	141	0.211	2300 6/29	282	0.431	2300 8/25	131	0.196	2300 8/7	417	0.594	230 6/9
NO_2	100	(0.05)	Annual Arith. Mean	Primary and Secondary[1/]	0	2[3/]	0.001[3/]	NA	——	——	——	2	0.001[3/]	NA	——	——	——
Ozone	160	(0.08)	1 hr max.	Primary and Secondary[1/]	5	134	0.068	1200 7/7	——	——	——	179	0.089	1900 8/29	——	——	——
SO_2	365	(0.14)	24 hr max.	Primary[1/]	0	38	0.014	1700 7/31	3	0.001	2200 7/17	14	0.005	0400 7/31	49	0.018	210 7/1
SO_2	80	(0.03)	Annual Arith. Mean	Primary[1/]	NA	8[3/]	0.003[3/]	NA	3	0.001[3/]	NA	3	0.001[3/]	NA	21	0.008[3/]	NA
SO_2	1300	(0.5)	3 hr max.	Secondary[1/]	0	114	0.043	1600 7/31	8	0.003	0100 7/17	52	0.019	0700 7/30	163	0.060	210 7/1
SO_2	15[6/]	(0.005)	24 hr max.	State[2/]	258	38	0.014	1700 7/31	3	0.001	2200 7/17	15	0.005	0400 7/31	49	0.018	210 7/1
Particulates	260		24 hr max.	Primary[1/]	0	212	NA	7/3	95	NA	6/24	247	NA	8/17	141	NA	6/2
Particulates	75		Annual Geo. Mean	Primary[1/]	NA	23[4/]	NA	NA	18[4/]	NA	NA	47[4/]	NA	NA	36[4/]	NA	NA
Particulates	150		24 hr max.	Secondary[1/]	3	212	NA	7/3	95	NA	6/24	247	NA	8/17	141	NA	6/24
Particulates	60		Annual Geo. Mean	Secondary[1/]	NA	23[4/]	NA	NA	18[4/]	NA	NA	47[4/]	NA	NA	36[4/]	NA	NA

Table 2.1-2. (Continued).

Parameter	Standard		Time Interval	Type of Standard	No. of Times Exceeded During Quarter	Site 1 Max. Measured			Site 2 Max. Measured			Site 3 Max. Measured			Site 4 Max. Measured		
						Value			Value			Value			Value		
	μg/m3	(ppm)				μg/m3	ppm	Time	μg/m3	ppm	Time	μg/m3	ppm	Time	μg/m3	ppm	Time
Particulates	150[7]		24 hr max.	State[2]	3	162	NA	7/3	73	NA	6/24	189	NA	8/17	108	NA	6/24
Particulates	45[7]		Annual Arith. Mean	State[2]	NA	30[3]	NA		22[3]	NA		45[3]	NA		36[3]	NA	

[1] Environmental Protection Agency Regulations on national primary and secondary ambient air quality standards (40 CFR 50; 36 FR 22384, November 25, 1971; as amended by 38 FR 25678, September 14, 1973; 40 FR 7042, February 18, 1975).

[2] Ambient air standards for metropolitan Denver air quality control region, air quality control areas, and the State of Colorado; Adopted: September 10, 1970, Effective: December 17, 1970.

[3] Arithmetic mean of values measured during the quarter.

[4] Geometric mean of values measured during the quarter.

[5] All EPA standards are at reference conditions of 25 C and 760 mm mercury.

[6] Reference conditions of 0 C and 760 mm mercury.

[7] Measured at ambient temperature and pressure.

NA = Not Applicable.

— Not measured at this site.

Seasonal minimum, maximum, and mean values for all air quality parameters, summer 1975 are presented in Table 2.1-3.

Table 2.1-3 indicates that the seasonal mean values for CO, NO, NO_x, and SO_2 are comparable to the standards associated with those atmospheric constituents with the exception of the State SO_2 standard. These compounds, found in the air around Tract C-a, are in quantities close to the lower limit of detectability. Measured levels of hydrocarbons and ozone are close to the maximum levels established by Regulatory standards. The levels of these compounds appear to be background, and not associated with man's activity. The hydrocarbon (both methane and nonmethane) concentrations remain relatively constant throughout the day, while the ozone exhibits definite dirunal variations with a maximum at about noon and a minimum at about midnight. Inter-site comparisons between the same parameters show good agreement.

Table 2.1-4 gives the particulate concentration data for the quarter for each site. The large variation between samples and sites is expected. Considerable fugitive dust is due to activities on site and dust from the road. For example, Site 3 is not far from the well-traveled road, which may be the source of the high values obtained at Site 3. The high values at Site 1 are probably due to more activity at this site and the 200-foot knoll, a short distance southwest, from which airborne dust could settle over the site.

Excessive amounts of particulates which exceeded Federal Secondary and State of Colorado Air Quality Standards (150 ug/m^3) were occasionally measured on windy days.

Particle size data by concentration and particle size range are given in Table 2.1-5. These data show that a large portion of the particulate weight is made up of particles of 0 to 0.95 micron. The values indicated by 0.30 ug/m^3 are less than the uncertainities of the measurement technique.

The results of particle trace element analysis on a particulate sample taken during the quarter are given in Table 2.1-6.

Table 2.1-3. Air quality parameters, seasonal summary for Summer 1975, RBOSP.

Parameter	Units	Minimum	Maximum	Arithmetic Mean
SITE 1				
O_3	ppm	0.000	0.068	0.037
CO	ppm	0.004	3.241	1.102
NO	ppm	0.000	0.039	0.004
NO_x	ppm	0.000	0.032	0.005
CH_4	ppm	0.879	1.196	1.048
THC	ppm	0.971	1.301	1.142
H_2S	ppm	0.000	0.002	0.002
SO_2	ppm	0.001	0.057	0.003
Particulates	μg/m^3	3.92	211.47	22.69[1]
SITE 2				
CH_4	ppm	0.045	1.000	0.918
THC	ppm	0.934	1.296	1.115
H_2S	ppm	0.000	0.002	0.000
SO_2	ppm	0.000	0.011	0.001
Particulates	μg/m^3	0.92	95.40	17.64[1]
SITE 3				
O_3	ppm	0.003	0.059	0.032
CO	ppm	0.033	2.532	0.505
NO	ppm	0.000	0.034	0.005
NO_x	ppm	0.000	0.056	0.006
CH_4	ppm	0.811	1.330	1.055
THC	ppm	0.900	1.818	1.147
H_2S	ppm	0.000	0.007	0.001
SO_2	ppm	0.000	0.023	0.001
Particulates	μg/m^3	13.12	247.03	46.88[1]
SITE 4				
CH_4	ppm	0.549	1.200	1.003
THC	ppm	0.741	1.359	1.134
H_2S	ppm	0.001	0.016	0.004
SO_2	ppm	0.002	0.031	0.008
Particulates	μg/m^3	5.58	140.83	35.53[1]

[1] Geometric mean

Table 2.1-4. Particulate concentration data for Summer 1975, values are presented in $\mu g/m^3$, RBOSP.

Month	Day	Year	Site 1	Site 2	Site 3	Site 4
June	3	1975	6.25	26.85	37.28	49.42
	6		12.26	11.28	18.27	60.02
	9		9.32	10.24	13.49	10.79
	12		3.92	14.84	55.18	NA
	15		10.05	20.72	120.97	42.37
	18		90.25	54.87	103.86	120.36
	21		46.66	44.94	13.12	54.38
	24		75.35	95.40	74.68	140.83
	27		24.22	61.68	89.09	123.73
	30		50.46	52.24	62.17	89.15
July	3	1975	211.77	63.40	47.58	78.23
	6		207.36	32.56	70.08	38.38
	9		13.36	35.13	50.28	38.38
	12		42.98	34.52	37.40	47.52
	15		44.70	39.67	48.31	57.63
	18		40.37	33.29	57.14	63.70
	21		18.83	33.91	54.26	21.15
	24		38.75	15.88	34.64	25.51
	27		17.78	15.94	38.14	21.77
	29		11.47	12.57	24.22 1/	40.22
August	2	1975	13.89	50.83	136.48	22.87
	5		9.38	0.12	23.85	16.31
	8		28.82	12.57	66.58	38.57
	11		19.01	11.65	61.00	42.67
	14		7.85	12.39	37.65	5.58
	17		19.60	0.92	247.03	10.67
	20		13.49	9.38	77.80	21.52
	23		12.63	4.84	19.01	33.29
	26		5.95	1.23	27.04	19.19
	29		15.88	1.16	26.43	14.04

1/Taken July 30, 1975.

Table 2.1-5. Particulate concentration by equivalent aerodynamic diameter[1/] for Summer 1975. Values are presented in $\mu g/m^3$, RBOSP.

Size Range (microns)	6/3	6/15	6/27	7/9	7/21	8/2	8/17	8/26
7.2 - ∞	<0.30	<0.30	<0.30	0.68	<0.30	<0.30	1.16	<0.30
3.0 - 7.2	<0.30	<0.30	<0.30	<0.30	<0.30	1.00	<0.30	<0.30
1.5 - 3.0	<0.30	<0.30	<0.30	<0.30	0.92	0.55	<0.30	<0.30
0.95 - 1.5	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
0 - 0.95	6.25	9.93	24.22	12.63	17.54	13.24	6.44	5.95

[1/] "Equivalent Aerodynamic Diameter" is defined as the size of a spherical particle of density 1 gm/cc, which has the same terminal settling velocity as the sampled particle.

Table 2.1-6. High volume filter, analytical trace element results for Summer 1975, RBOSP.

Parameter	Concentration (ng/cm^2)	Parameter	Concentration (ng/cm^2)	Parameter	Concentration (ng/cm^2)	Parameter	Concentration (ng/cm^2)
Uranium	Internal Standard	Terbium	<0.01	Ruthenium	<0.01	Vanadium	6.4
Thorium	<0.01	Gadolinium	<0.01	Molybdenum	13	Titanium	510
Bismuth	<0.01	Europium	<0.01	Niobium	1.4	Scandium	<0.42
Lead	19	Samarium	<0.01	Zirconium	5.6	Calcium	~3500
Thallium	<0.01	Neodymium	<0.01	Yttrium	2.1	Potassium	<1240
Mercury	0.1	Praseodymium	0.23	Strontium	12	Chlorine	<67
Gold	<0.01	Cerium	11	Rubidium	9.5	Sulfur	<520
Platinum	<0.01	Lanthanum	2.8	Bromine	<1.6	Phosphorus	170
Iridium	<0.01	Barium	56	Selemium	0.37	Silicon	~75000
Osmium	<0.01	Cesium	0.16	Arsenic	<0.62	Aluminum	~2100
Rhenium	Internal Standard	Iodine	<0.01	Germanium	<0.01	Magnesium	~1500
Tungsten	<0.01	Tellurium	<0.01	Gallium	1.7	Sodium	<740
Tantalum	<0.01	Antimony	0.25	Zinc	36	Fluorine	62
Hafnium	<0.01	Tin	5.1	Copper	470	Oxygen	NR*
Lutecium	<0.01	Indium	Internal Standard	Nickel	<75	Nitrogen	NR*
Ytterbium	<0.01	Cadmium	<0.01	Cobalt	<7	Carbon	NR*
Thullium	<0.01	Silver	<0.01	Iron	~1400	Boron	NR*
Erbium	<0.01	Palladium	<0.01	Manganese	<38	Beryllium	<0.01
Holmium	<0.01	Rhodium	<0.01	Chromium	<28	Lithium	37
Dysprosium	<0.01						

*NR - Not reported.

2.2 Meteorology

The meteorological studies are designed to at least meet and, in some cases, exceed environmental lease stipulations.

The RBOSP meteorological data acquisition system is integrated into the network described in Section 2.1. It includes instrument towers at Sites 1, 2, 3, and 4. Data transmission from the remote sites and recording methods are similar to those utilized in the air quality studies, i.e., hard copy reports are provided hourly, and continuous analog records are made for each parameter.

The Central Station is located at Site 1, which has a 60-m meteorological tower. Wind speed, wind direction, air temperature and relative humidity are measured at the 10-m level. Ambient temperature, wind speed, and wind direction are measured at the 30- and 60-m levels, and the temperature differences between the 10- and 60-m levels are recorded. Additionally, precipitation and solar radiation are monitored at ground level at Site 1.

All meteorological parameters are measured continuously. The data are averaged during the last 15 minutes of each hour and entered into the computer file.

The following parameters are not part of the automatic data acquisition system, but are monitored routinely or seasonally at Site 1

- Evaporation rate
- Snow depth and water content
- Particulates
- Visibility

At each of remote sites 2, 3, and 4 there is a 10-m meteorological tower. Wind speed, wind direction, and ambient air temperature are measured at the 10-m level.

A seasonal upper air study measuring winds and temperatures to an elevation of 13,000 feet above MSL is scheduled over Tract C-a for the first five quarters of the program. These studies performed by manually tracking pilot balloons with a theodolite and aircraft-mounted temperature sensors, provide basic information on the mean mixing layer height above Tract C-a.

Tracer diffusion studies designed to track dispersion of the tracer material in the lower atmosphere to evaluate modeling predictions and lead to a better understanding of terrain effects will be conducted. Ambient noise level measurements will also be taken.

All the data obtained are used to define the baseline atmospheric conditions and for application in the appropriate diffusion models used to predict the effects of shale oil operations on ambient air quality.

The baseline meteorological program is established at two atmospheric levels, referred to in this report as lower air studies and upper air studies. The lower air studies include data obtained at the four station networks; the upper air studies involved obtaining data on the winds aloft and vertical temperature profiles. Upper air studies are performed on a seasonal basis. Tracer studies are performed during the baseline study period concurrently with upper air wind and temperature samplings. Studies which provide useful information, but do not fall into these categories are: precipitation, evaporation, solar radiation, noise, and visibility (discussed under Miscellaneous, Section 2.2.3).

2.2.1 Lower Air Studies

Lower air studies refer to the meteorological data acquired from the four station ground networks and include wind speed, direction, and temperature at 10-m above the surface at all four monitoring sites. Relative humidity at 10-m, wind speed, wind direction, and air temperature at 30 and 60-m above the surface at the main monitoring site are also included.

2.2.1.1 Objectives

No change has occurred since Progress Report 3. See section 2.2.1 in Progress Report 3 for specific objectives.

2.2.1.2 Methods

No change has occurred since Progress Report 3. See section 2.2.1.2 in Progress Report 2 for specific methods used in the meteorological lower air studies.

2.2.1.3 Results

The 1975 summer season summaries of the minimum, maximum and mean values of the meteorological parameters measured at each site are presented in Table 2.2-1. The composite hour is the mean of the data taken during a particular hour of the day for all days of the month. A composite day defines the minimum, maximum, and mean values for 24 composite hours of a month. The minimum and maximum listed are the individual hourly averages which are greater than or less than all other hourly averages. Wind at Sites 1 and 2 (10-m level) were predominantly from the southwest during summer 1975. The mean wind speeds were 7.58 and 9.06 mph, respectively. Although Sites 1 and 2 are at about the same elevation (7,400 feet above MSL) the local terrain at Site 2 is relatively flatter than at Site 1.

Table 2.2-1. Meteorological parameters seasonal summary for Summer 1975, RBOSP.

Parameter	Units	Minimum	Maximum	Mean
SITE 1				
Wind Speed (10 m)	mph	0.70	30.79	7.58
Wind Speed (30 m)	mph	0.57	37.05	8.85
Wind Speed (60 m)	mph	0.56	41.05	10.19
Wind Direction Sigma (10 m)	degrees	0.01	59.26	12.17
Air Temperature (10 m)	C	1.40	30.07	17.29
Air Temperature (30 m)	C	1.05	27.00	16.85
Temperature Difference (60 to 10 m)	C	-4.69	4.74	0.14
Relative Humidity (10 m)	%	10.00	86.72	25.52
SITE 2				
Wind Speed (10 m)	mph	0.62	36.70	9.06
Air Temperature (10 m)	C	1.47	27.47	16.86
SITE 3				
Wind Speed (10 m)	mph	0.96	29.90	7.10
Air Temperature (10 m)	C	-2.39	28.97	15.50
SITE 4				
Wind Speed (10 m)	mph	0.59	31.23	6.20
Air Temperature (10 m)	C	-2.97	33.14	16.82

The Site 2 monitoring location is the highest point within a radius of approximately 1 km. The 10-m level of the main meteorological tower at Site 1 is approximately 50-m lower than the elevation of several knolls within several hundred meters. The increased terrain influence at Site 1 is probably responsible for the lower mean wind speed.

Mean wind speeds at Sites 3 and 4 for the summer 1975 period were 7.10 and 6.20 mph, respectively. Sites 3 and 4, below plateau levels, are situated in the approximate centers of Corral Gulch and Yellow Creek Gulch at elevations of 6,570 and 6,280 feet above MSL. Corral Gulch runs in a west to east direction. Yellow Creek Gulch runs in a south-southwest to north-northwest direction.

The diurnal variation of mean wind speed is shown in Figures 2.2-1 to 2.2-6 for each site. Mean wind speeds average 4 to 7 mph higher during daytime hours with Sites 3 and 4 showing the larger variation. This is probably due to valley locations for those sites and to a larger temperature diurnal variation. The 69-m level has about a 7 mph higher wind speed during the day than at night. During June, there was a double peak for the 60-m mean wind speed, one occurring from 0000 to 0300 and one during the daylight hours. The daytime maximum mean was about 6 mph greater than the nighttime peak. The minimum mean, occurring around 0700, was about 9 mph less than the peak occurring at 1300.

The wind direction sigma, diurnal variation, at the 10-m level, Site 1 is shown in Figure 2.2-7. The peak on the maximum wind direction sigma curve, about 59 degrees, is one isolated occurrence. No explanation for this point can be made except it can only be associated with highly variable wind conditions.

Wind rose data for summer 1975 are presented for all four monitoring stations in Figures 2.2-8 through 2.2-11.

Wind rose data (10-m level) from Sites 1 and 2 are comparable. The reduced frequency of occurrence of southwest winds relative to south-southwest and west-southwest winds is probably caused by the influence from a small knoll about 200-m southwest of Site 1. Extreme terrain-induced wind channeling effects exist at Sites 3 and 4. Winds at Site 3 are predominantly from the west, which is in agreement with the westerly course of Corral Gulch. The predominant winds at Site 4 are from the south-southwest, corresponding to the orientation of Stake Springs Draw and Yellow Creek. In addition to the terrain-induced channeling of the gradient winds at Sites 3 and 4, valley drainage flows probably contribute significantly to the direction of winds.

The term gradient wind is used here to describe wind flows resulting from a pressure difference between two points at the same elevation, while the term valley drainage flow is used to describe the winds resulting from radiative cooling of the near surface layers of air which produces a subsiding, downslope flow.

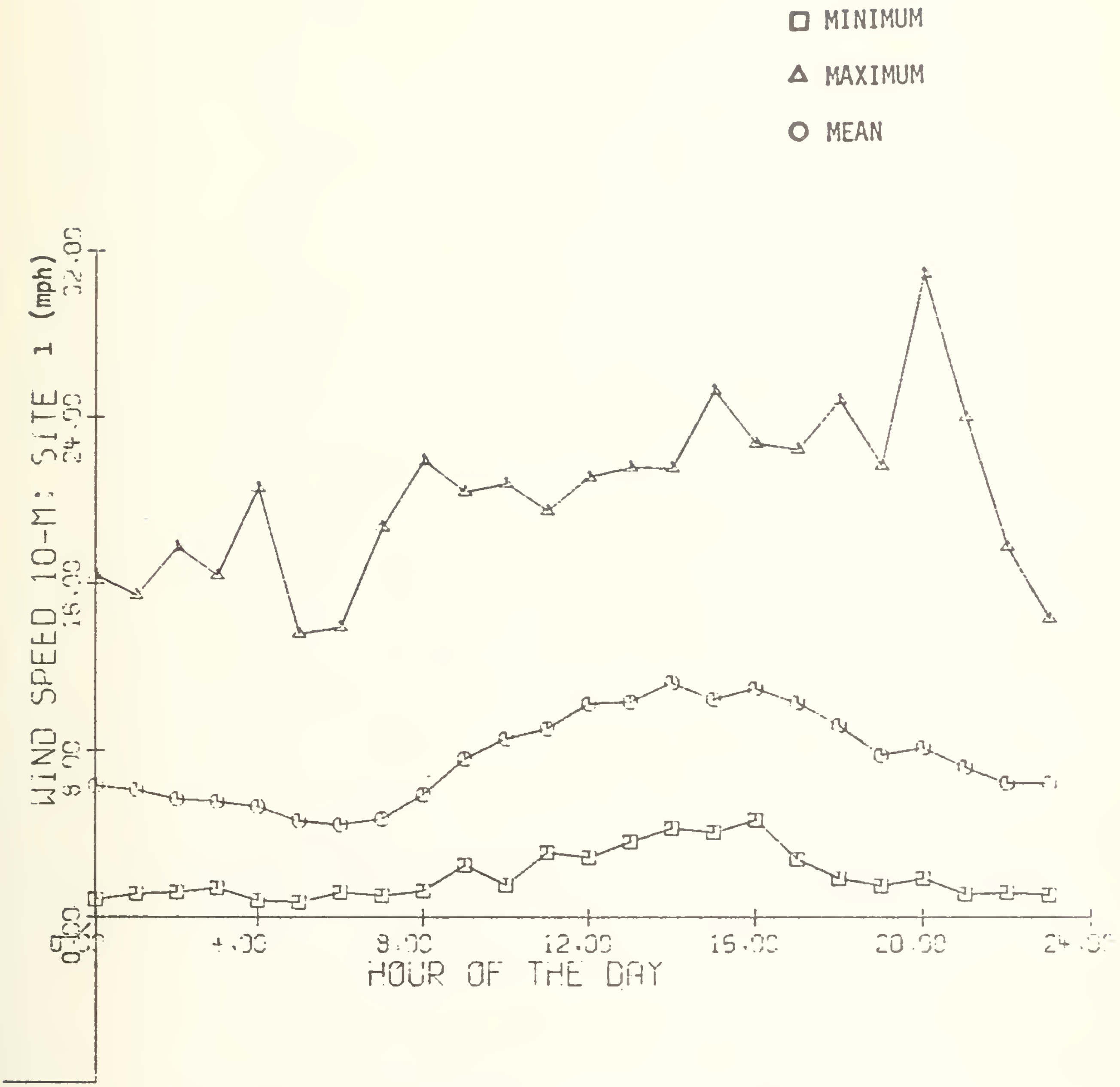


Figure 2.2-1. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

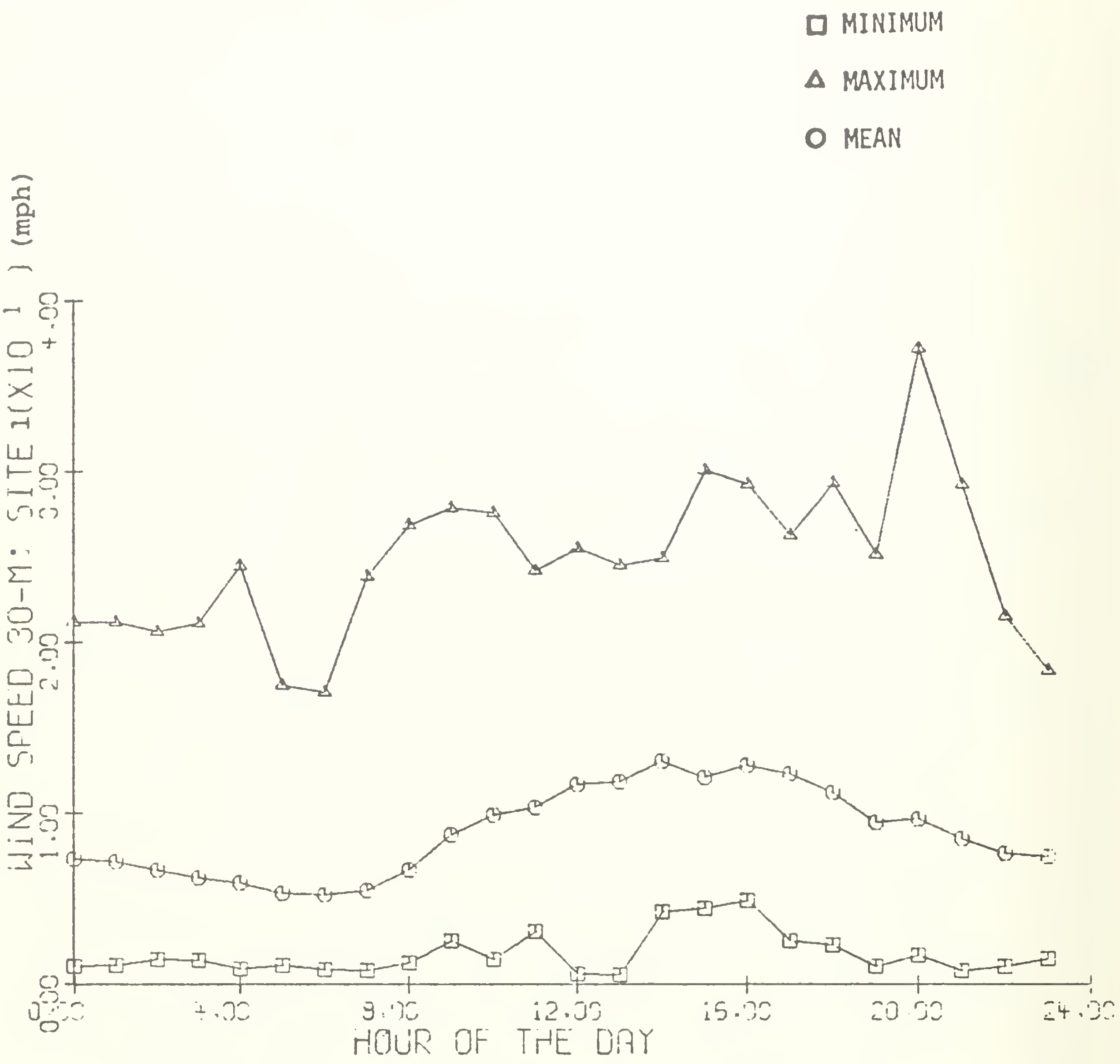


Figure 2.2-2. Wind speed, 30-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

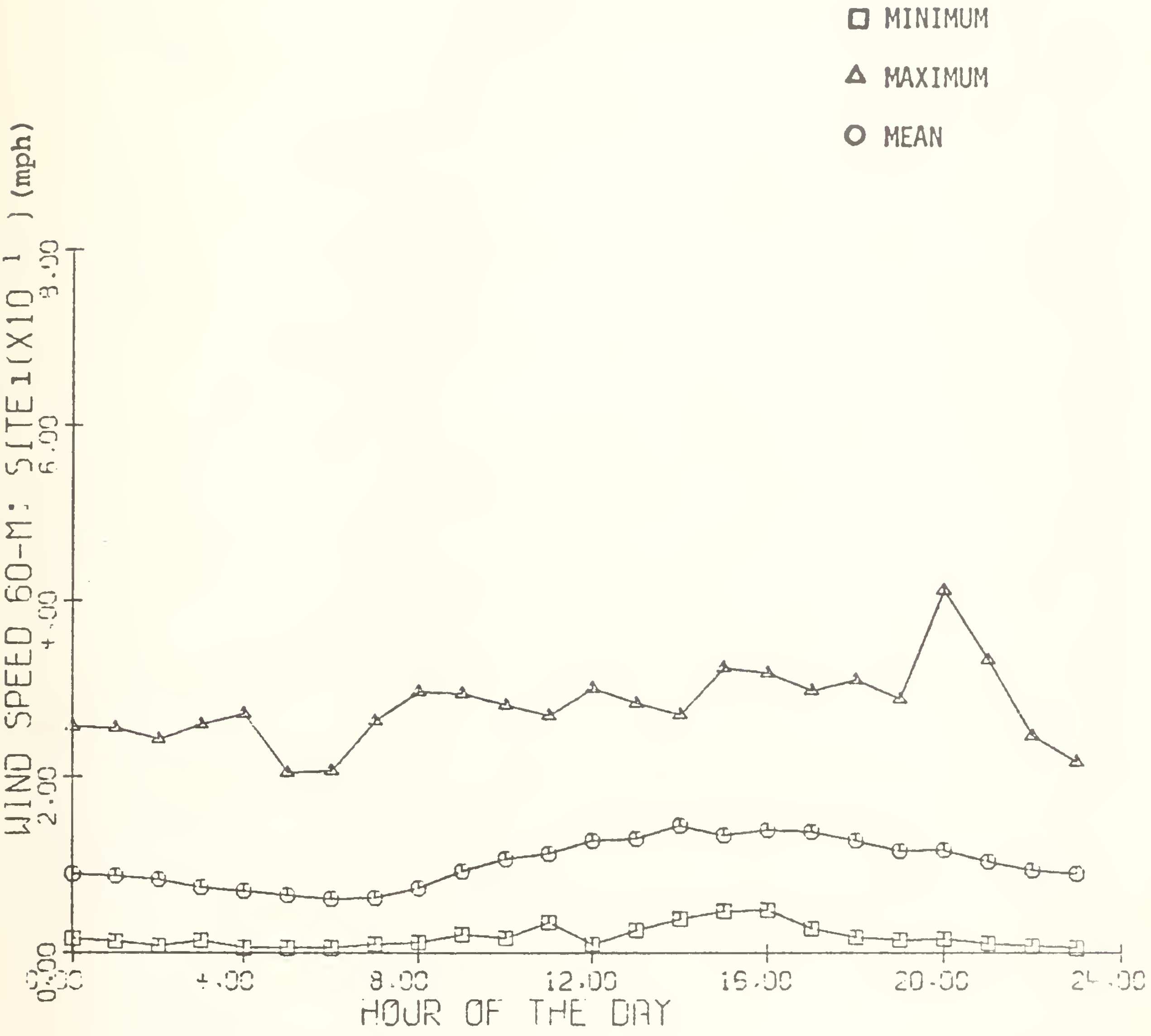


Figure 2.2-3. Wind speed, 60-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

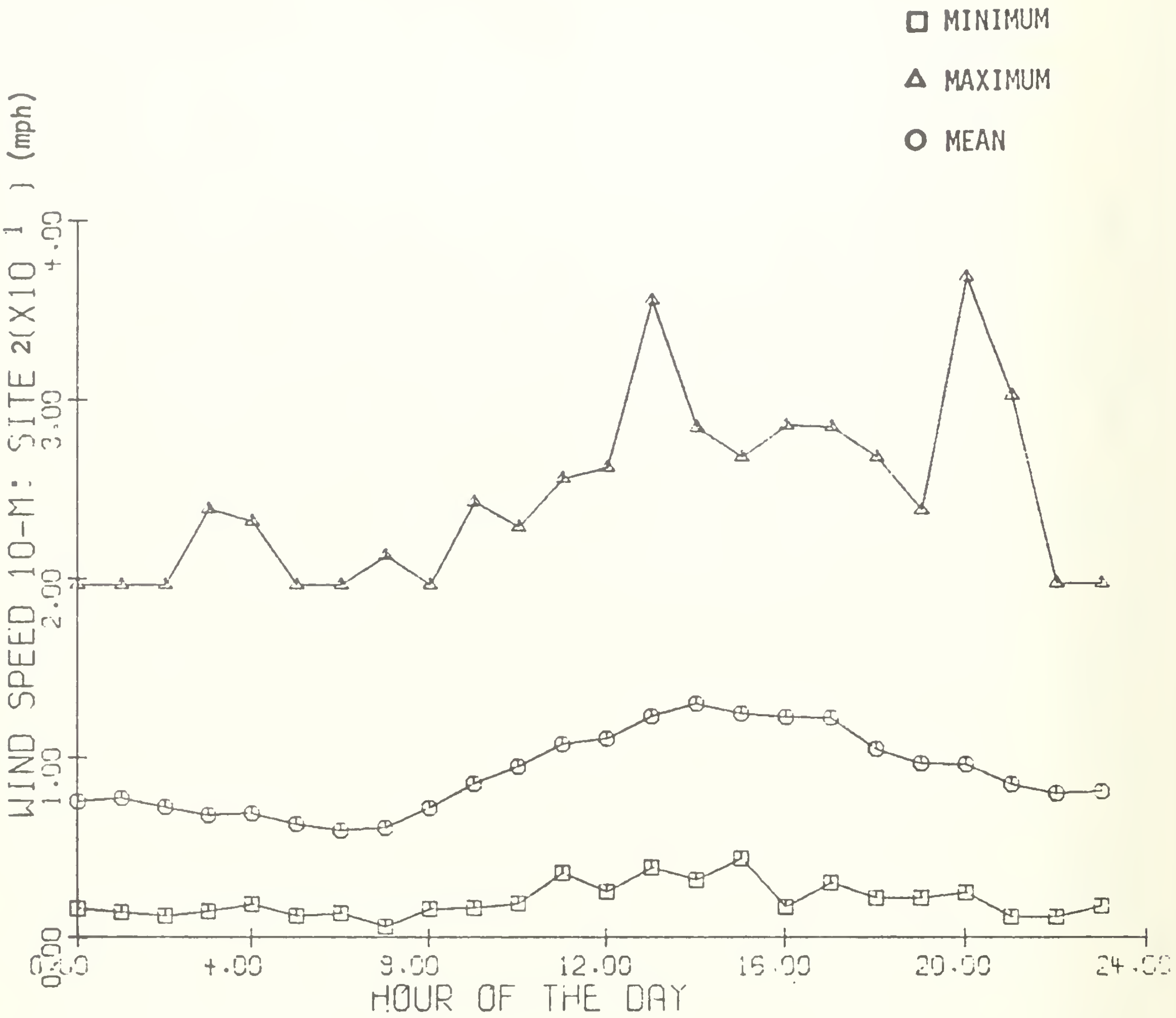


Figure 2.2-4. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 2, RBOSP.

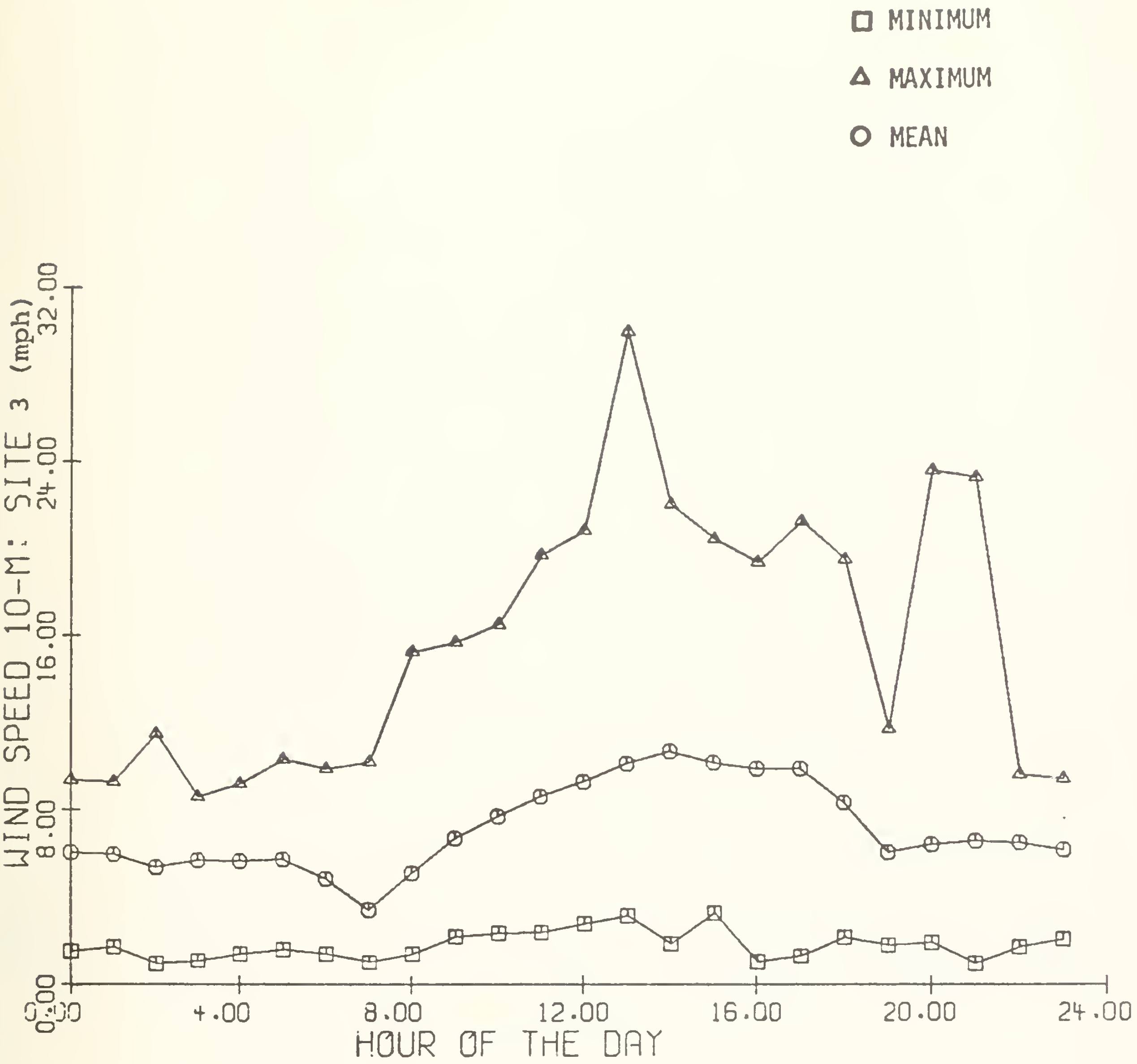


Figure 2.2-5. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 3, RBOSP.

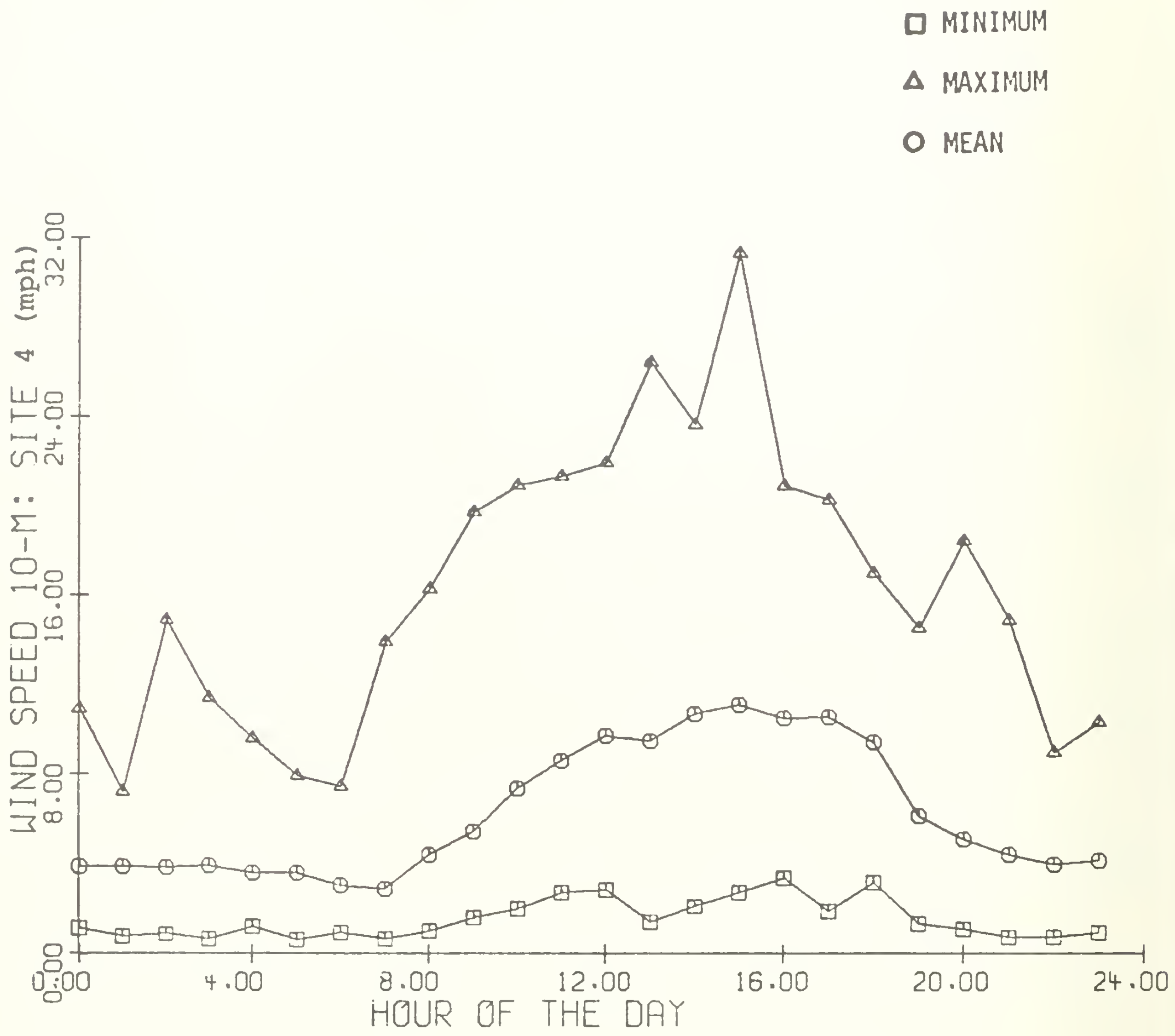


Figure 2.2-6. Wind speed, 10-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 4, RBOSP.

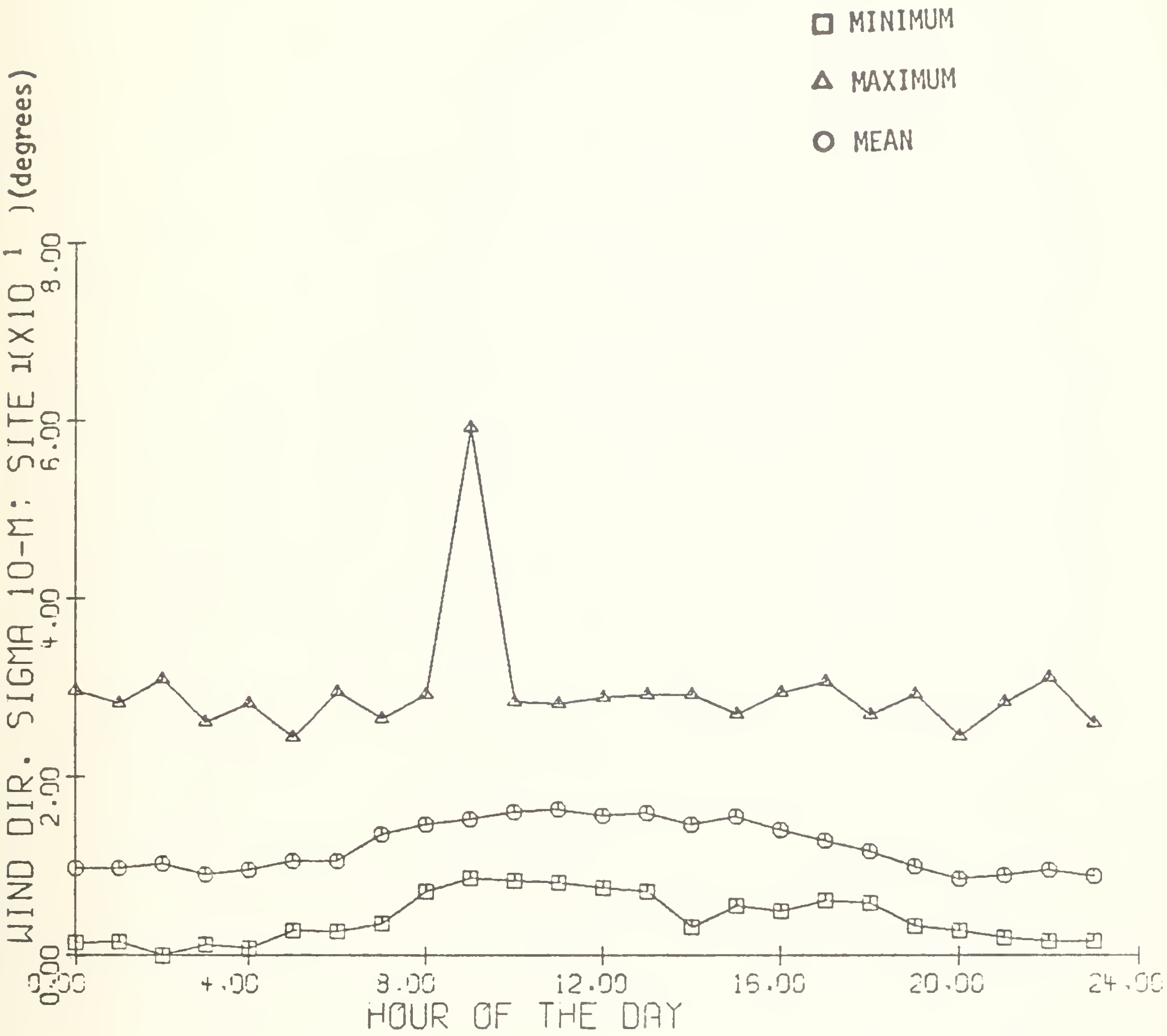
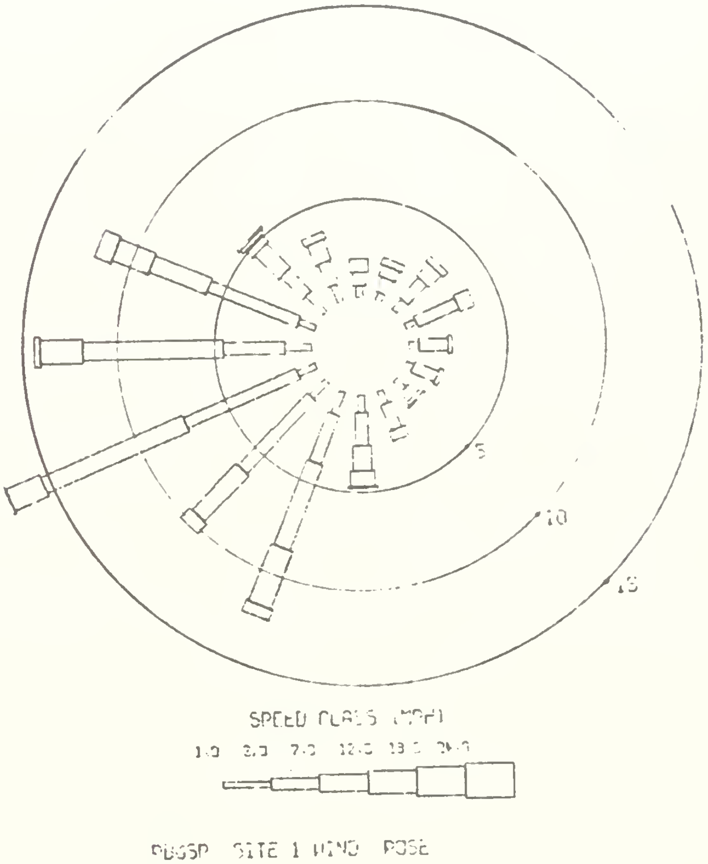
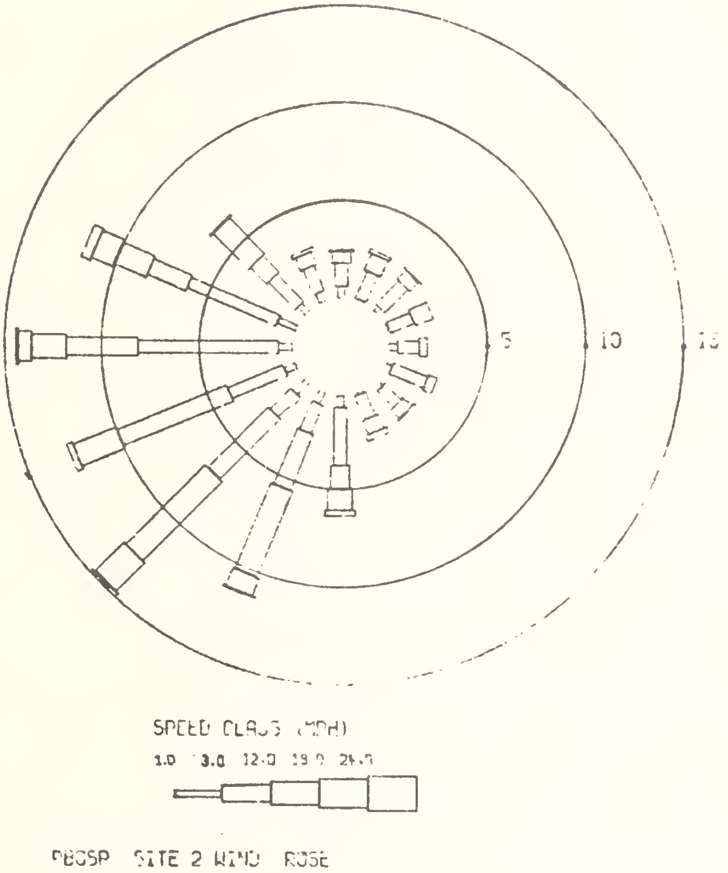


Figure 2.2-7. Wind direction sigma, 10-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.



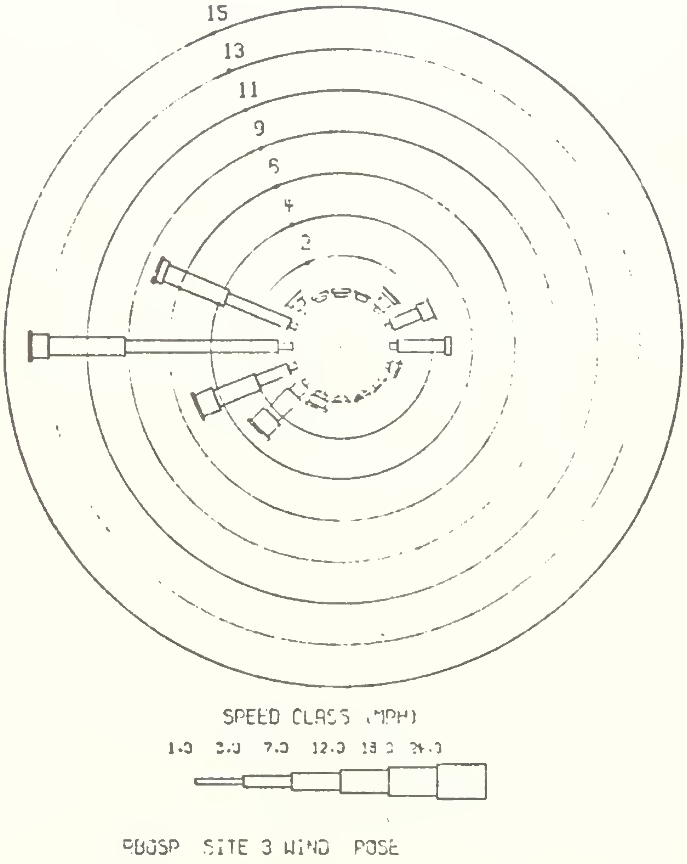
10 m
Summer

Figure 2.2-8. Summer 1975 wind rose from the 10-m level at Site 1, RBOSP.



Summer

Figure 2.2- 9. Summer 1975 wind rose from the 10-m level at Site 2, RBOSP.



Summer

Figure 2.2- 10. Summer 1975 wind rose from the 10-m level at Site 3, RBOSP.

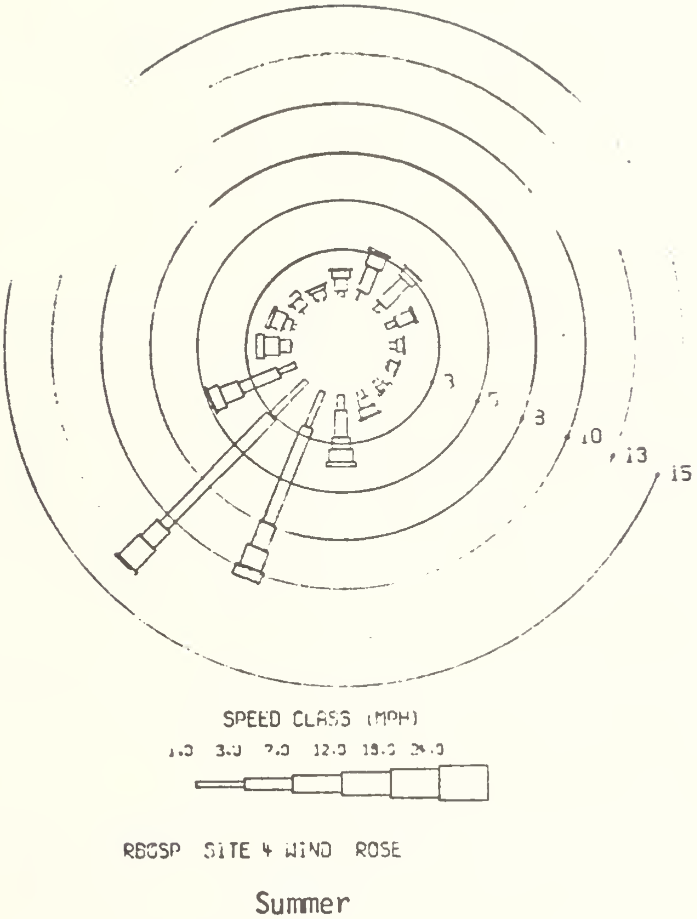


Figure 2.2-11. Summer 1975 wind rose from the 10-m level at Site 4, RBOSP.

A least squares fit to the mean seasonal wind speed as a function of height at the 60-m tower (Site 1) was done to investigate the applicability of the logarithmic wind profiles:

$$\bar{u} = \frac{u_*}{K} \ln \left(\frac{Z}{Z_o}\right)$$

where Z_o is the roughness parameter, K is the von Karman constant, and u_* is the friction velocity. The seasonal data fit the logarithmic wind profile to a high degree of confidence (coefficient of determination = r^2 - 0.98) with u_*/K = 1.42 mph and Z_o = 5.3 cm. Z = height above ground (in meters).

The minimum, maximum, and mean values of air temperature as a function of the hour of the day for each of the four sites for the summer season are plotted in Figures 2.2-12 through 2.2-16.

The valley sites (3 and 4) have a much larger diurnal temperature variation than the plateau sites (1 and 2). The intensity of the cold portion of the composite days at Sites 3 and 4, in relation to that at Sites 1 and 2, is much greater. This is probably because of cold air valley drainage flows. The composite day air temperature data for Sites 3 and 4 indicate that more cold air accumulates at Site 4 than at Site 3. The 200-foot elevation difference and the Stake Spring Draw air flow, as well as the Corral Gulch air flow draining into the Yellow Creek Gulch, contribute to this intensity difference.

Although there is a substantial difference in the diurnal variation among all sites, the average temperatures over each month and the season agree well (to within 1.42 C) between sites.

Atmospheric stability was determined from temperature difference measurements made between the 10-m and the 60-m level on the main meteorological tower at Site 1. Figure 2.2-17 presents the minimum, maximum, and mean composite day temperature differences as a function of the time of day for the summer season 1975.

These data indicate that the mean-surface inversion is relatively weak (about a -0.61 C difference in temperature) during the interval from 2100 hours MST in the evening until 0600 hours MST the following moning. When the break-up of the mean surface inversion occurs, atmospheric stability becomes significantly unstable. The intensities of the most stable inversions are about the same as those of the most unstable conditions.

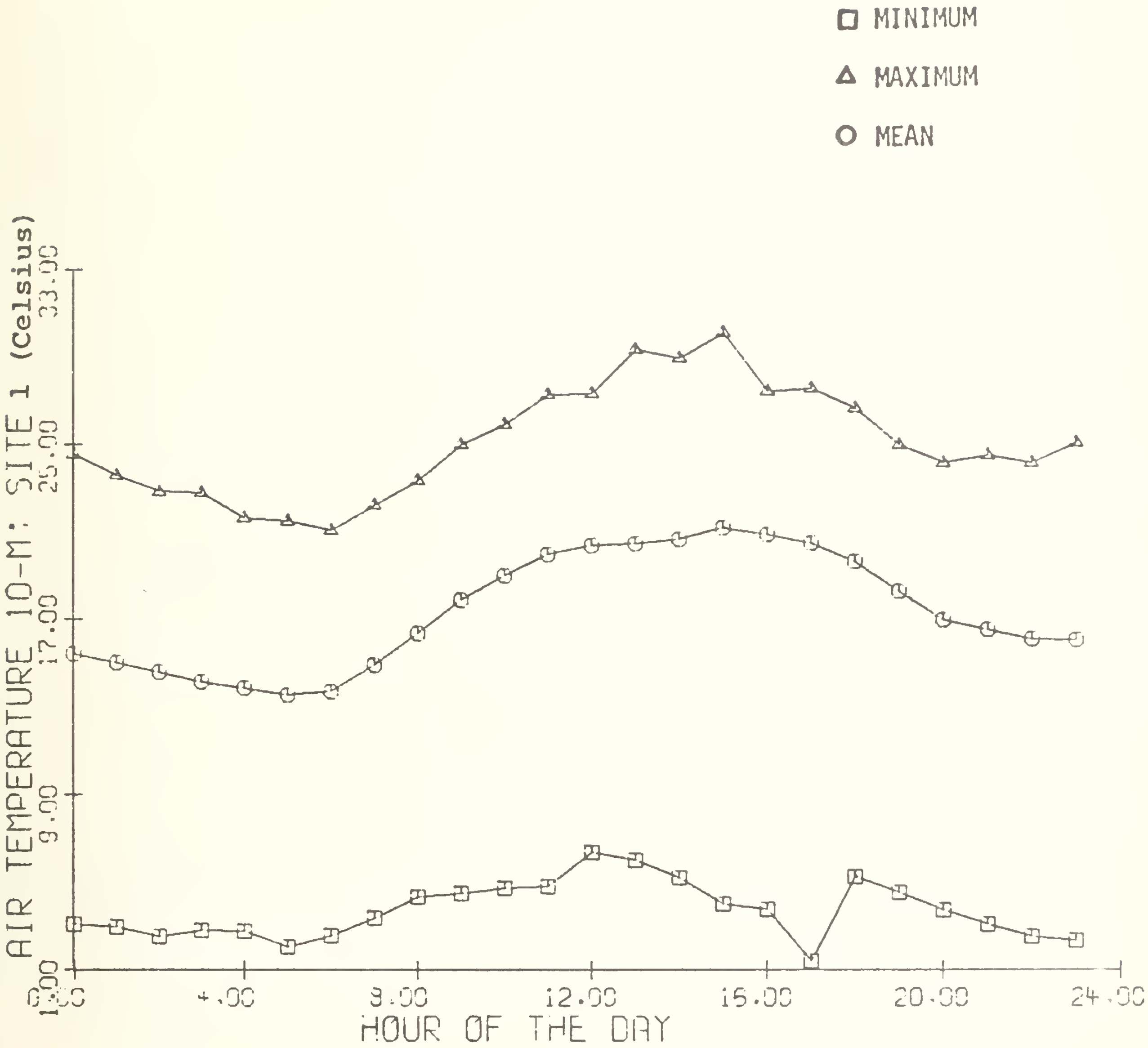


Figure 2.2-12. Air temperature, 10-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

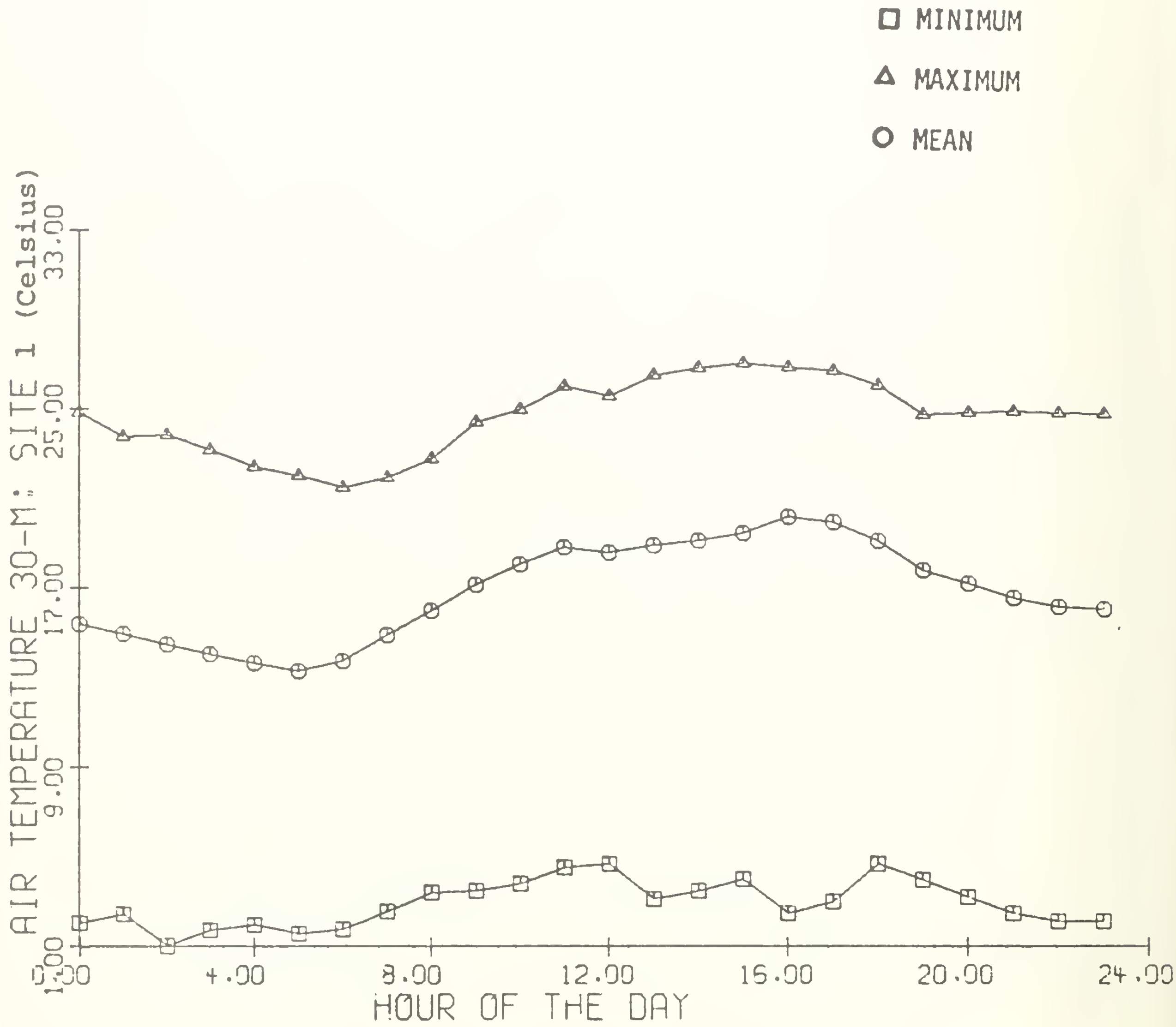


Figure 2.2-13. Air temperature, 30-m level (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

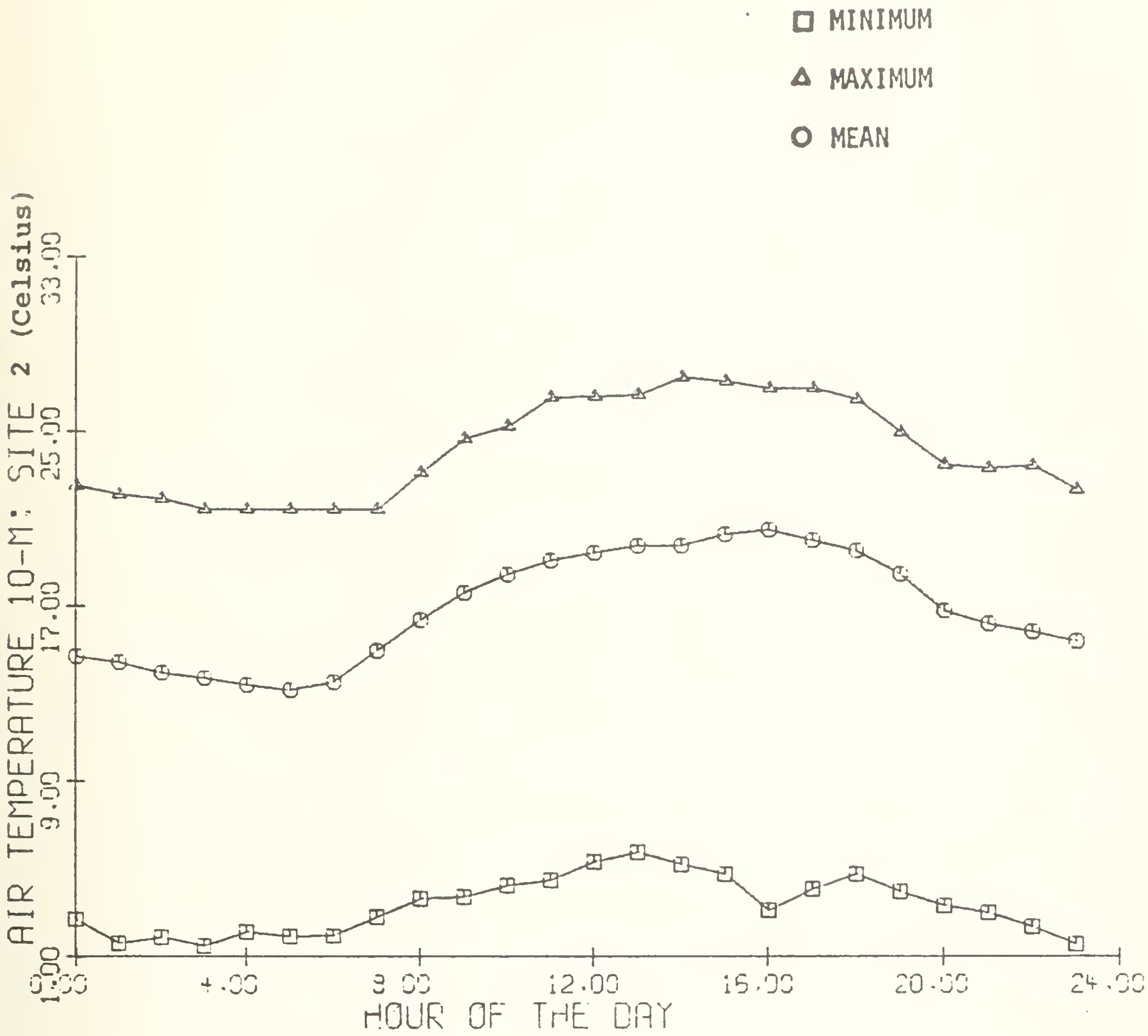


Figure 2.2-14. Air temperature (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 2, RBOSP.

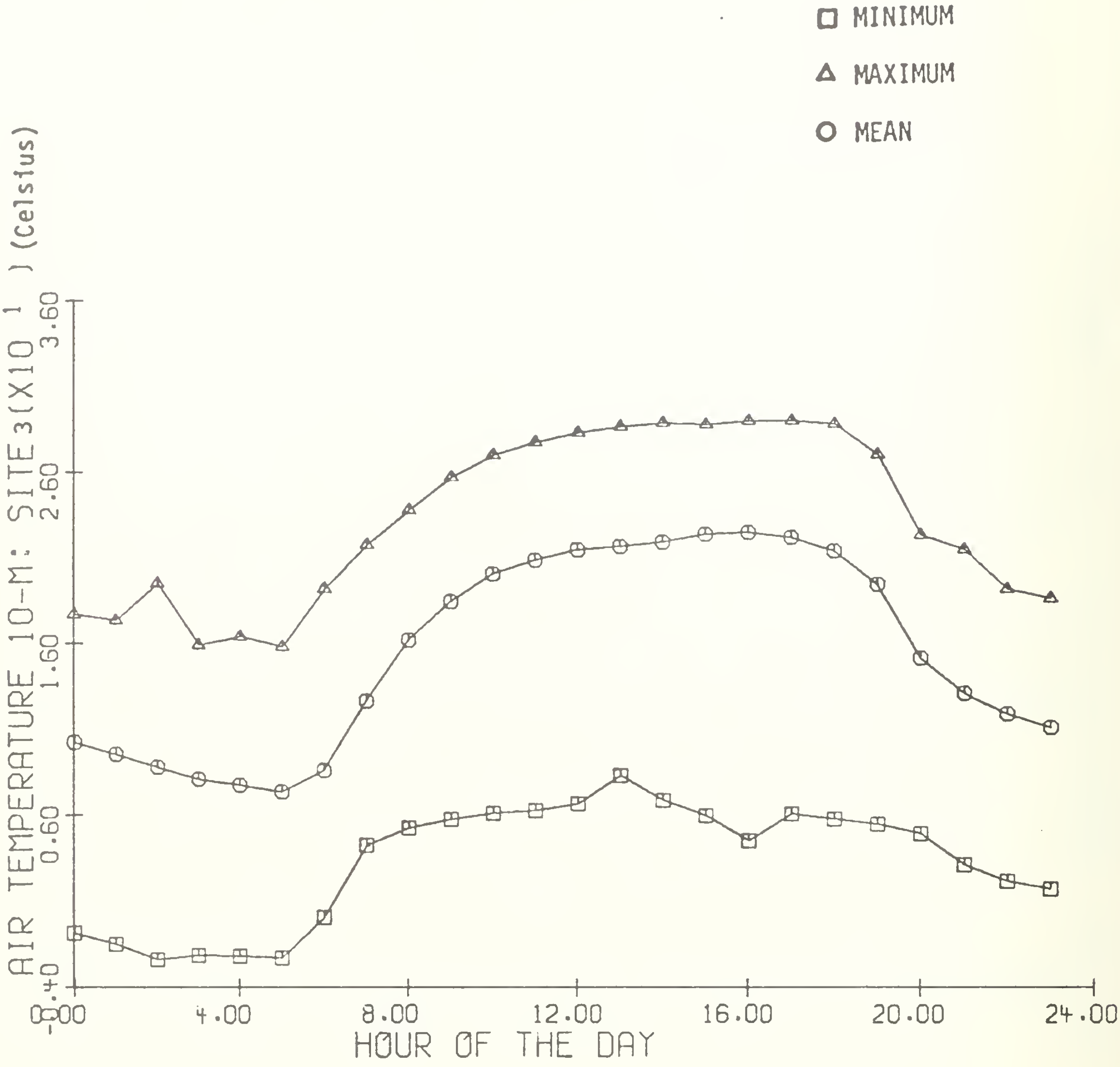


Figure 2.2-15 Air temperature (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 3, RBOSP.

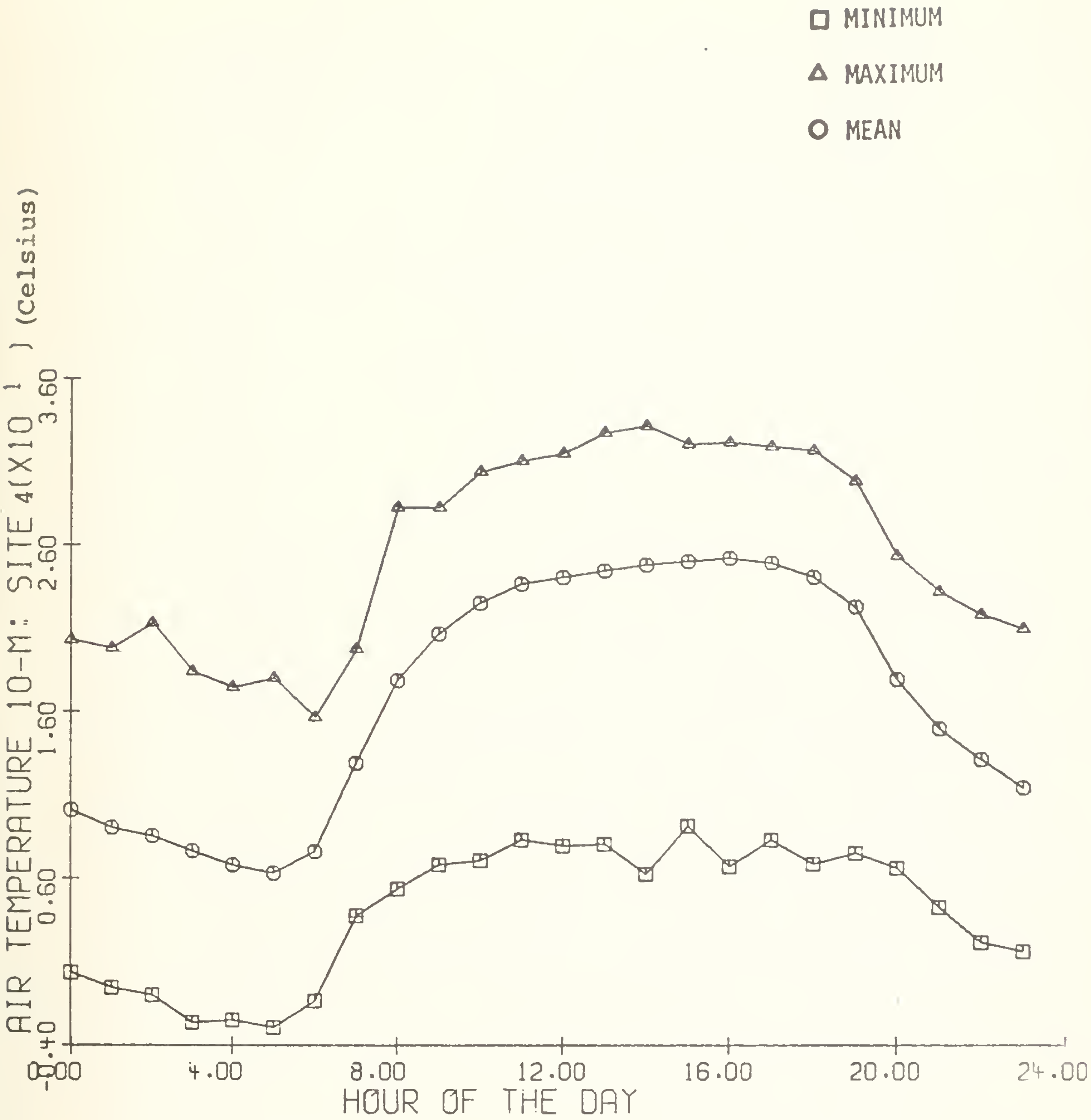


Figure 2.2-16 Air temperature (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 4, RBOSP.

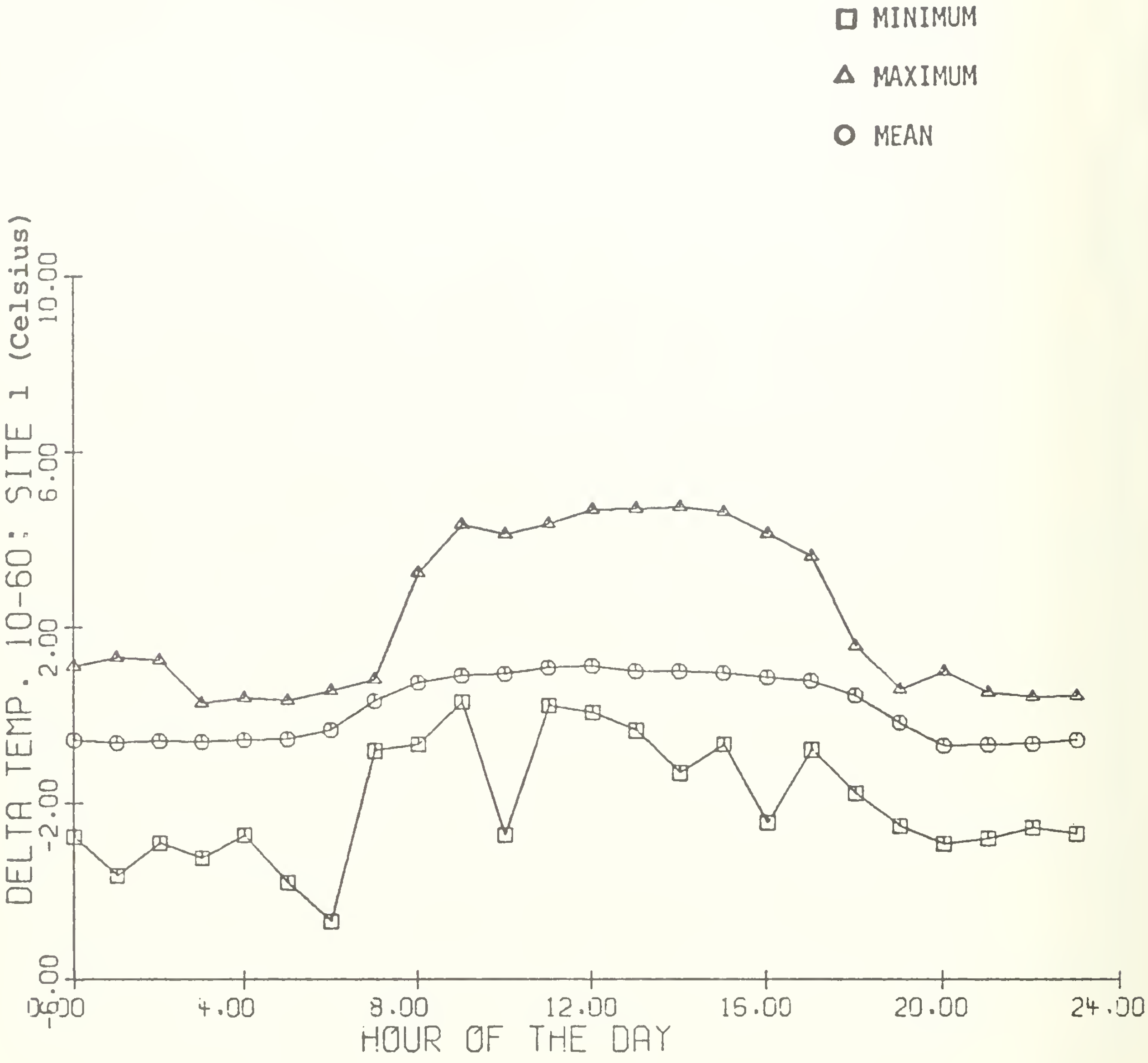


Figure 2.2-17. Temperature difference between the 10-m and 60-m levels (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

The percent of occurrence of the modified Pasquill stability categories for summer 1975 and associated mean wind speeds are presented in Table 2.2-2. Stability categories were calculated according to the following criteria:

Stability Index	Temperature change (C) with heights per 100 m
A	-1.9
B	$-1.9 \geq \Delta T < -1.7$
C	$-1.7 \geq \Delta T < -1.5$
D	$-1.5 \geq \Delta T < -0.5$
E	$-0.5 \geq \Delta T < 1.5$
F	$1.5 \geq \Delta T < 4.0$
G	$4.0 \geq \Delta T$

The wind speeds, as a function of stability category, show a definite relationship. Categories A and G have the highest average wind speeds and E has the lowest. The slightly stable Category E occurred on the average during nighttime hours with F and G occurring in early morning around 0600.

Figure 2.2-18 graphically presents the minimum, maximum, and mean composite day relative humidities as a function of hour of day for summer 1975. The relative humidity data were taken at the 10-m level at Site 1. There was a significant decrease (35% to 23%) in the average relative humidity at sunrise. The effect is probably due to the rapid surface heating of the air, although the transition period takes over 2 hours. The decrease may also arise from the increased thermally generated turbulent mixing caused by the reversal of the average lapse rate from slightly stable to slightly unstable and the increased surface temperature.

2.2.2 Upper Air Studies

2.2.2.1 Ojectives

The period of performance of the field work was from 12 July through 26 July 1975. No other change has occurred since Progress Report 3. See section 2.2.2.1 for specific objectives.

2.2.2.2 Methods

No change has occurred since Progress Report 3. See section 2.2.2.2 in Progress Report 2 for specific methods.

Table 2.2-2. Percent of occurrence of the Pasquill stability classes at Site 1. Stability category determined from the temperature difference between the 10- and 60-m levels during the Summer 1975, RBOSP.

Stability Classification	Pasquill Categories	Temperature Change with Height (C/100 m)	Percent of Occurrence	Mean Wind Speed (mph)
Extremely Unstable	A	Less than -1.9	18.38	10.26
Moderately Unstable	B	-1.9 to -1.7	6.72	8.98
Slightly Unstable	C	-1.7 to -1.5	6.11	8.05
Neutral	D	-1.5 to -0.5	18.19	7.84
Slightly Stable	E	-0.5 to 1.5	35.54	5.60
Moderately Stable	F	1.5 to 4.0	13.20	7.59
Extremely Stable	G	Greater than 4.0	1.87	9.09

SOURCE: David H. Slade, Editor, Meteorology and Atomic Energy
Nat. Tech. Infor. Ser. TID-24190, pp. 102-103, 1971

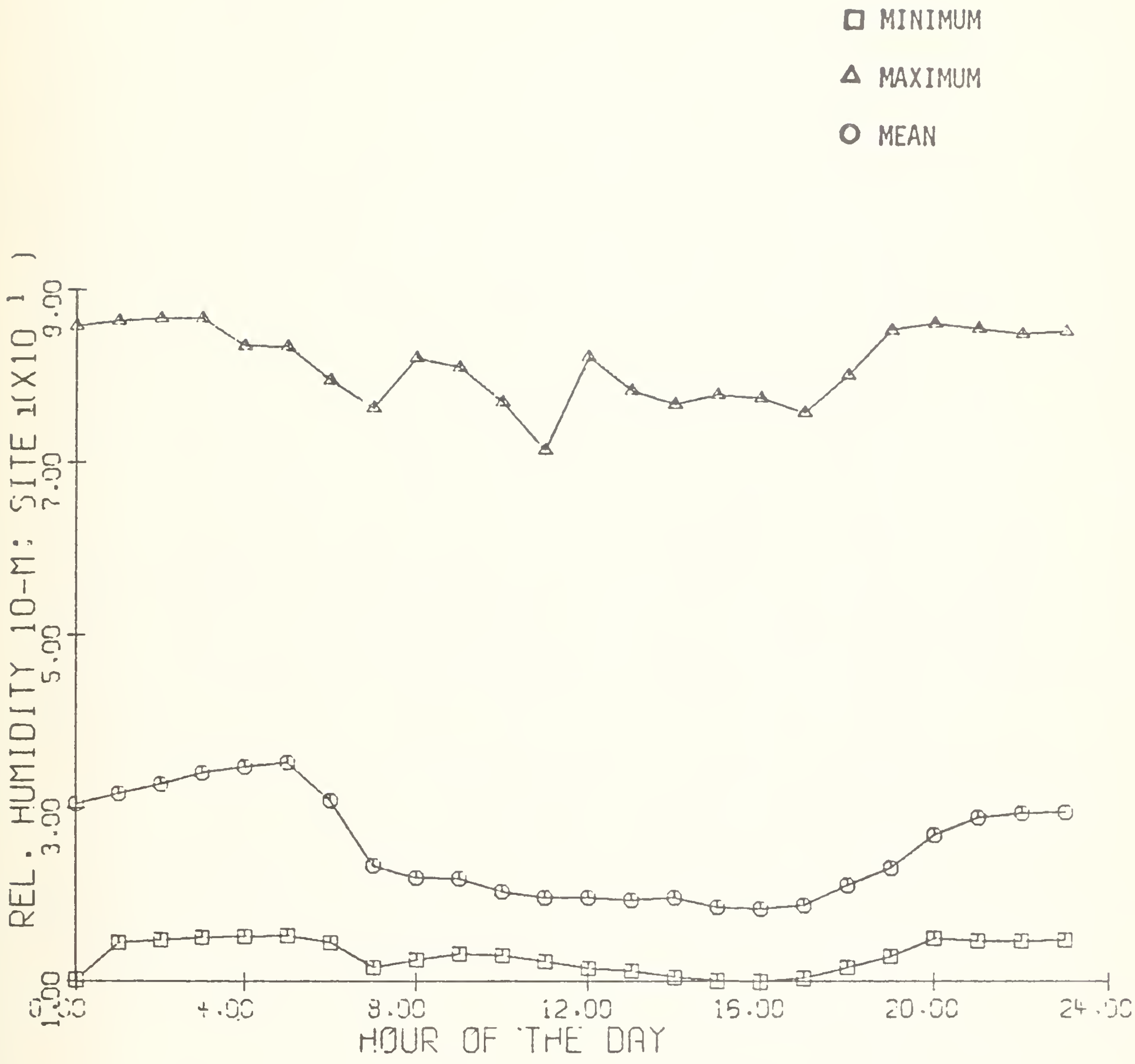


Figure 2.2-18. Relative humidity (percent), minimum, maximum, and mean by hour of the day for Summer 1975 at Site 1, RBOSP.

2.2.2.3 Results[1]

The temperature structure over Tract C-a followed the dry adiabatic lapse rate higher than 1,000 feet above the surface in the absence of inversions and a wet adiabatic behavior during periods of nearby thunderstorm activity with few surface-based stable layers. The air from the surface to the 1,000-foot level exhibited a complex profile with inversions in the morning hours, which broke up by early morning on each measurement day. Temperature inversions were quite pronounced in the valleys below Tract C-a, but none were greater than 2.4 C/100 m (Pasquill, Category F). The average mixing layer depth in the presence of a surface inversion at the early morning sounding (0500 MST) was 1,000 feet above the base of the main meteorological tower over Tract C-a. By 0800 MST, all surface inversions above the tract had dissipated; however in 10 instances, the inversion remained within the valleys below the tract. Comparison with the fall 1974 (AL-ECP-74-108), winter 1974 (AL-EC-118), and spring 1975 (ECR-75-004) upper air data indicates that there are significant differences in the mixing layer heights and intensites when a surface inversion is present.

Several flights to determine the horizontal temperature structure at constant altitude, but at varying heights (depending upon terrain), showed little horizontal dependence even when these were performed in the presence of a surface inversion. However, surface-based measurements of the actual temperature indicate that large horizontal temperature gradients probably exist when a surface-based vertical temperature inversion is present. The large horizontal temperature gradients observed are limited (about 100 feet) in vertical extent above the surface.

The wind structure above Tract C-a depends heavily upon the upper (500-mbar) level flows as well as the detailed surface topography, which is complex. In general, the upper level winds were predominantly from the southwest, although light variable winds from all directions were represented during the study period. In addition, wind speeds during the early morning hours were less than and not as gusty as those recorded later in the day.

Temperature soundings were made in valleys during the day to investigate the temperature structure of air at lower elevations than the main monitoring site. These soundings indicate that, in most cases, when an inversion was present, the inversion intensity at the lower levels was more severe than at the proposed plant altitude. An example of this behavior is shown in the temperature profiles taken at 0500 on 14 July 1975. Of the 15 days of data collection, all showed evidence of isothermal or inversion conditions. The summer study showed only a single day with precipitation actually falling at the tract, although 10 days exhibited scattered thunderstrom activity within about a 15-mile radius. Although surface-based inversions were present every morning, they never persisted through the second sounding above the tract; however, in 10 instances, the inversions remained in the valley below the tract past 0800 MST. Inversions were not present during the late morning and afternoon soundings.

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[1] For a more complete description of the processes involved and a more extensive summary, refer to EG&G Report No. ECR-75-017, 15 September 1975, "Upper Air Comparison Studies for Summer 1975 between Federal Oil Shale Tracts C-a, C-b and Grand Junction, Colorado. These reports are available in the Area Oil Shale Office.

The aircraft and Site 1 tower temperature measurements show large differences which follow a simple pattern. In the early morning, the surface temperature was colder than the sounding temperature value at the absolute elevation of the surface-based measurement. During the mid- and late-morning soundings, the instantaneous surface measurements were in agreement with the sounding measurements taken at the same elevation. During the afternoon, the surface temperature was usually higher than the sounding temperature at the same elevation. The pattern is probably caused by strong surface cooling and heating. This pattern is not reflected in the fall or winter upper air data.

In the winter 1974 Upper Air sutdy (AL-EC-118), substantial horizontal temperature gradients were postulated to account for the discrepancy between surface measurements and sounding measurements made at the same elevation, but horizontally displaced about 1 km. At that time, one horizontal sounding showed no horizontal temperature dependence. During the spring study, seven additional horizontal temperature soundings were made (in the presence of inversions). These also showed no significant horizontal temperature structure.

As a continuing effort in the investigation of the depth and extent of these horizontal temperature gradients, special flights were made through the Piceance Creek basin during the summer 1975 study. These horizontal flights were only made when a surface-based inversion was present (early morning sounding). Comparison of the vertical temperature structure over the tract with the results of the horizontal soundings indicates (even with moderate to strong inversions present) that the horizontal temperature variation is less than 2°C. Horizontal gradients of the magnitude postulated (but not measured by the aircraft) in the winter 1974 upper air study were not found in any of the horizontal flights during summer 1975.

These horizontal temperature gradients (measured by surface-based stations), are extremely limited in their vertical extent above the surface. Because the aircraft typically flew within 100 to 200 feet above the surface over the same surface measurement stations, the horizontal gradients are apparently below this level.

2.2.3 Miscellaneous

The meteorological parameters grouped into this category are precipitation, evaporation, solar radiation, noise, visibility, and tracer studies. All these parameters, except precipitation and evaporation, are measured only at Site 1. Evaporation measurement is made at Site 3 because of water availability. The evaporation rate and visibility are not monitored continuously, but are recorded on a routine basis.

2.2.3.1 Precipitation Measurements

2.2.3.1.1 Objectives

No change has occurred since Progress Report 2. See Section 2.2.3.1.1 in Progress Report 2 for specific methods used in the precipitation measurements.

2.2.3.1.2 Methods

No change has occurred since Progress Report 2. See Section 2.2.3.1.2 in Progress Report 2 for specific methods used in the precipitation measurements.

2.2.3.1.3 Results

The precipitation data summary for summer 1975 is presented in Table 2.2-3. The total and daily amounts of precipitation are shown for each site. Maximum total precipitation for 1 day was 0.38 inch at Site 4 on 16 July 1975.

Site 4 registered the largest total precipitation (1.04 inches) for the summer 1975 season.

2.2.3.2 Evaporation Measurements

2.2.3.3.1 Objectives

No change has occurred since Progress Report 2. See section 2.2.3.2.1 in Progress Report 2 for specific objective of the evaporation measurements.

Table 2.2-3. Precipitation data for Summer 1975, values are presented in inches of water, RBOSP.

Date	Site 1 Total	Site 2 Total	Site 3 Total	Site 4 Total
6/03/75	___	0.01		
6/04/75	___		0.01	0.01
6/07/75	___		0.01	0.01
6/08/75	0.03	0.01		0.08
6/09/75	0.01			0.04
6/10/75				0.01
6/18/75			0.04	0.07
6/20/75			0.03	0.11
6/21/75		0.01	0.03	0.02
6/22/75				0.05
6/26/75	0.01			
June Total	0.05	0.03	0.12	0.44
7/03/75				
7/04/75	0.01			
7/08/75		0.01		
7/09/75	0.01			0.07
7/10/75			0.02	
7/11/75	0.01			
7/12/75			0.04	
7/15/75			0.01	0.04
7/16/75		0.01		0.38
7/17/75				0.01
7/21/75				0.01
7/29/75	0.01		0.01	0.01
7/31/75				0.04
July Total	0.04	0.03	0.08	0.56
8/06/75	0.01			
8/12/75			0.01	
8/14/75			0.07	
8/16/75	0.01			
8/19/75				0.01
8/22/75			0.01	0.03
8/27/75			0.04	
August Total	0.02	0.00	0.13	0.04
Summer Total	0.11	0.06	0.33	1.04

2.2.3.2.2 Methods

No change has occurred since Progress Report 2. See section 2.2.3.2.2 in Progress Report 2 for specific methods used in the evaporation measurements.

2.2.3.2.3 Results

Data for the summer season are presented in Table 2.2-4. The data for the period 14 June to 21 June were lost because range cattle disturbed the monitoring site. The highest evaporation rate recorded was 0.034 g/cm^2/hr. This occurred during the week ending 14 June. The minimum evaporation rate was 0.011 g/cm^2/hour during the measurement period ending 19 July 1975.

2.2.3.3 Solar Radiation Measurement

2.2.3.3.1 Objectives

No change has occurred since Progress Report 2. See section 2.2.3.3.1 in Progress Report 2 for specific objectives of the solar radiation measurements.

2.2.3.3.2 Methods

No change has occurred since Progress Report 2. See section 2.2.3.3.2 in Progress Report 2 for specific methods used in the solar radiation measurements.

2.2.3.3.3 Results

The minimum, maximum, and mean composite day solar radiation measurements as a function of hour of the day for summer 1975, are graphically presented in Figure 2.2-19. The hourly means follow a close approximation to a sine curve. The minimum, maximum, and mean hourly solar radiation measurements are presented in Table 2.2-5.

Table 2.2-5. Solar radiation, seasonal and monthly summary for Summer 1975, values are in Langleys or cal/cm^2/min, RBOSP.

	June	July	August	Summer 1975
Minimum	0.00	0.00	0.00	0.00
Maximum	1.90	1.70	1.62	1.90
Mean	0.45	0.39	0.42	0.42

Table 2.2-4. Evaporation data summary for Summer 1975, RBOSP.

End Date of Measurement Period	Time of Measurement Hours (MST)	Precipitation Since Last Reading (inches)	Maximum Temperature Since Last Reading (Degrees Celsius)	Minimum Temperature Since Last Reading (Degrees Celsius)	Water Required to Fill Pan (inches)	Evaporation Rate ($g/cm^2/hr$)
June 21						[1]
June 28	1215	0.03	27.8	5.6	2.08	0.032
July 5	1015	0.00	32.2	11.1	2.025	0.031
July 12	1338	0.06	34.4	17.8	0.850	0.014
July 19	0948	0.01	32.2	15.6	0.680	0.011
July 26	1730	0.00	27.2	23.3	1.80	0.026
August 2	1200	0.01	32.8	12.8	0.94	0.015
August 10	1800	0.00	26.1	7.2	2.59	0.033
August 16	1700	0.08	27.2	15.6	0.65	0.013
August 23	1800	0.01	28.9	11.7	1.69	0.026
August 30	0900	0.04	27.8	10.0	1.88	0.033

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[1] Domestic stock broached enclosure for evaporation pan. Pan relocated inside Site 3 security fence.

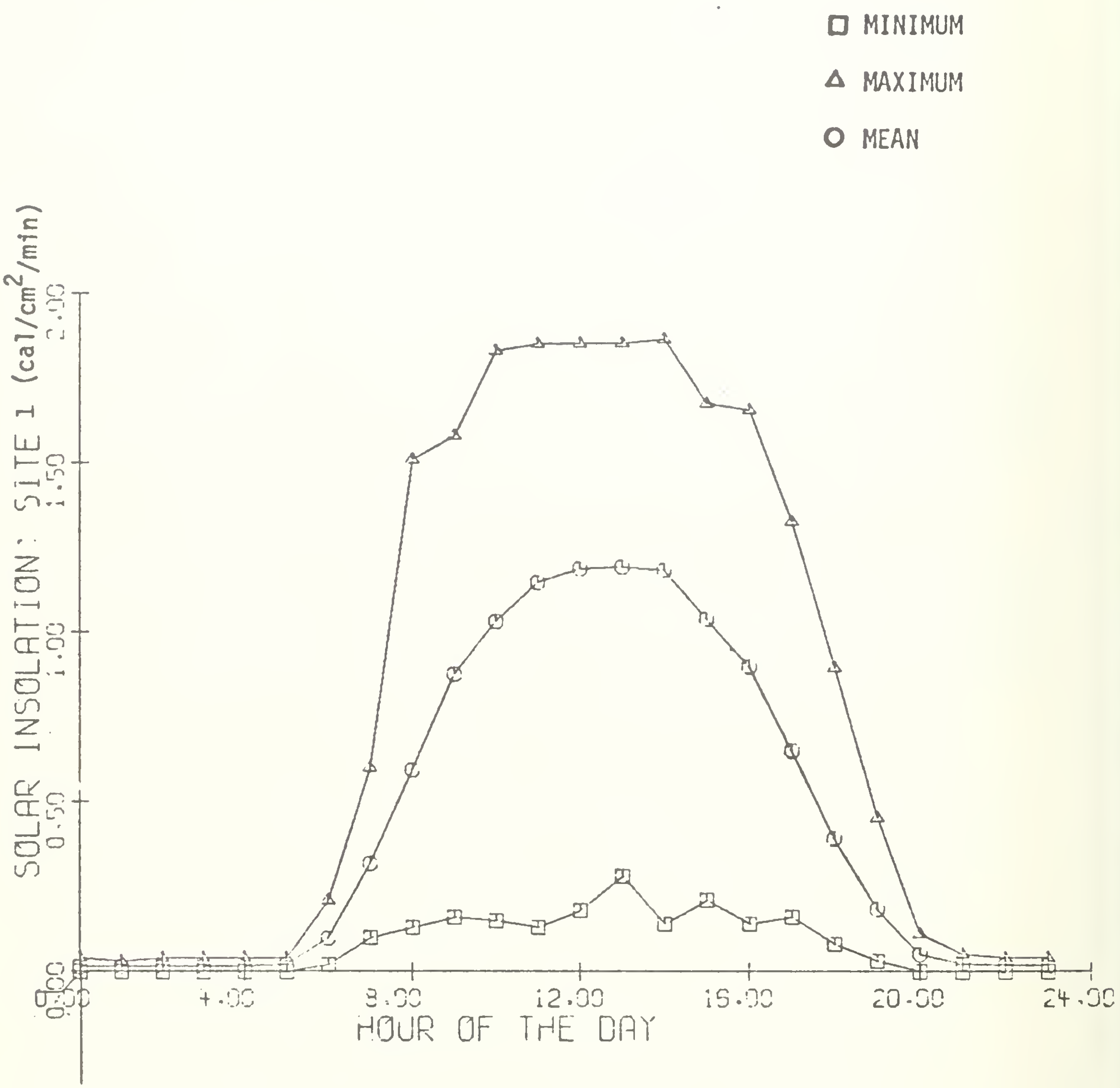

Figure 2.2-19. Solar radiation (minimum, maximum, and mean by hour of the day) for Summer 1975 at Site 1, RBOSP.

2.2.3.4 Noise Measurements

2.2.3.4.1 Ojbectives

No change has occurred since Progress Report 2. See section 2.2.3.4.1 in Progress Report 2 for specific objectives of the noise measurements.

2.2.3.4.2 Methods

No change has occurred since Progress Report 2. See section 2.2.3.4.2 in Progress Report 2 for specific methods used in the noise measurements.

2.2.3.4.3 Results

Noise level field measurements were in the process of being collected at the end of this quarter.

2.2.3.5 Visibility Measurements

2.2.3.5.1 Objectives

No change has occurred since Progress Report 2. See section 2.2.3.5.1 in Progress Report 2 for specific objectives of the visibility measurements.

2.2.3.5.2 Methods

No change has occurred since Progress Report 2. See section 2.2.3.5.2 in Progress Report 2 for specific methods used in the visibility measurements.

2.2.3.5.3 Results

During summer 1975, visibility ranged from 20 to 105 miles for each day that data were recorded. The 20-mile visibility occurred on 9 June 1975 when thundershowers were to the south of the site. On three other days visibility was limited to 80 miles, because of local thunderstorms. For most of the other periods of record, visibility was virtually unlimited (Tables 2.2-6 through 2.2-8).

2.2.3.6 Tracer Study Measurements

2.2.3.6.1 Objectives

No change has occurred since Progress Report 2. See section 2.2.3.6.1 in Progress Report 2 for specific objectives of the Tracer Study measurements.

Table 2.2-6. Visibility data for June 1975, RBOSP.

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours	Sector Visibility				Prevailing Visibility	Comments
			N	E	S	W		
June 3	1610	0	100	100	100	100	>100	Estimated cloud cover 80%.
June 6	1930	0	150	150	150	150	>150	Estimated cloud cover 10%.
June 9	1130	0	100	50	20	50	>50	Estimated cloud cover 70%. Thundershowers in area.
June 12	1000	0	150	150	150	150	>150	Estimated cloud cover 5%. Clear light winds 10 mph.
June 15	1000	0	100	100	100	100	>100	Estimated cloud cover 2%. Westerly wind at 10-20 mph.
June 18	1500		80	80	80	80	>80	Light rain, overcast.
June 21	0800	0	150	150	150	150	>150	Estimated cloud cover 10%. Clear with light clouds.
June 24	0745	0	150	150	150	150	>150	Estimated cloud cover 10%. Light winds at 8-10 mph. Clear with light clouds.
June 27	0900	0	150	150	150	150	>150	Light haze and southerly wind, no clouds.
June 30	1100	0	150	150	150	150	>150	Clear, no clouds. Light southwesterly winds.

Table 2.2-7 . Visibility data for July 1975, RBOSP.

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours	Sector Visibility				Prevailing Visibility	Comments
			N	E	S	W		
July 3	0805	0	150	150	150	150	>150	Estimated cloud cover 40%. Southeasterly winds at 10 mph.
July 6	1220	0	150	150	150	150	>150	Estimated cloud cover 3%. Northeasterly wind at 6 mph.
July 9	1630	0	30	80	80	80	>80	Estimated cloud cover 80%. Thunderstorms in area northwest to northeast.
July 12	0820	0	150	150	150	150	>150	Estimated cloud cover 80%. Light rain with very light northeasterly breeze.
July 15	1700	0	100	100	100	100	>100	Estimated cloud cover 50%. Thundershowers in vicinity.
July 18	1149	0	150	150	150	150	>150	Estimated cloud cover 5%. Light southwesterly breeze.
July 21	1620	0	150	150	150	150	>150	Estimated cloud cover 10%.
July 24	1100	0	80	80	80	80	>80	Estimated cloud cover 15%.
July 27	1320	0	150	150	150	150	>150	Estimated cloud cover 15%.
July 30	1100	0	150	150	150	150	>150	Estimated cloud cover 60%.

Table 2.2-8 . Visibility data for August 1975, RBOSP.

Date of Observation	Time of Observation Hours (MST)	Precipitation in Prior 24 Hours	Sector Visibility				Prevailing Visibility	Comments
			N	E	S	W		
August 2	1600	0	80	80	80	80	>80	Estimated cloud cover <5%. Light winds.
August 5	0945	0	80	80	80	80	>80	Clear.
August 8	1040	0	80	80	80	80	>80	Clear.
August 11	1200	0	80	10	80	80	>80	Estimated cloud cover 95%. Thunderstorms in area. Southwesterly winds at 10 mph.
August 14	1400	0	80	80	80	80	>80	Estimated cloud cover 90%. Thunderstorm activity.
August 17	1500	0.01 in.	100	100	100	100	100	Cloud cover 20%. Scattered small clouds plus light breeze.
August 20	0900	0	80	80	80	80	80	Slightly overcast and clearing.
August 23	0945	0	100	100	100	100	100	Winds from 205 degrees and 10-20 mph winds. Temperature is 20 C,60% cloud cover.
August 26	1105	0	150	150	150	150	150	Warm, sunny day. Light winds.
August 29	1800	0	100	100	100	100	100	Sunny day with no clouds and light winds from the south.

2.2.3.6.2 Methods

No change has occurred since Progress Report 2. See section 2.2.3.6.2 in Progress Report 2 for specific methods used in the Tracer Study Measurements.

2.2.3.6.3 Results

Tracer study measurements are scheduled for fall 1975.

2.3 Terrestrial Studies

The terrestrial program is designed to gather two years of baseline data on vegetation, small mammals, large mammals, mammalian predators, avifauna, herpetrofauna, invertebrates, domestic livestock, and threatened and endangered species. A variety of standardized methodologies is employed to gather these data in the field. All studies are designed to gather the definitive data necessary to describe existing ecosystems as required by the environmental stipulations in the oil shale lease.

2.3.1 Vegetation

2.3.1.1 Objectives

The objectives of vegetation investigations in the vicinity of Tract C-a are to identify the plant species present (floristics); define the structural and compositional organization of these species in recognizable associations (phytosociology); correlate floristics and phytosociology with environmental, biotic and historic usage factors; and map the predominant vegetation types. The emphasis in this progress report will be to present the floristic composition and phytosociology of predominant vegetation types sampled, noting the most important ecological relationships.

Plant specimens are collected to serve two objectives. The first is to obtain a voucher collection in the best possible condition of all species encountered in the study area. The second is to collect for laboratory identification any plant not identified to the species level in the field.

2.3.1.2 Methods

Aerial photographs and pertinent literature were used to identify the major vegetation types on and adjacent to Tract C-a. A preliminary selection of sampling locations in each type was made from aerial photographs to assure good coverage of the entire area and to insure access along existing roads and trails.

Each representative of a type thus selected (such as pinyon-juniper) was then surveyed on the ground and the most prevalent variants of the overall type (for example, pinyon-juniper with a sagebrush understory) were identified. The largest block of homogeneous vegetation of each variant was selected for sampling.

A modification of the line-strip technique as described by Woodin and Lindsey (1954), Lindsey (1955), and Potter (1957) is used during the phytosociological investigations.

Sixty-two, 100 x 6m transects are established within the major vegetaion types occurring both on the tract and in the surrounding area. Sampling of these transects is scheduled for May, July, and September, 1975 and 1976. Of these 62 transects, 35 are permanent transects in which only the herbaceous stratum is sampled again in subsequent sampling periods. These provide data on seasonal and annual vegetation changes for the herbaceous stratum. The remaining 27 non-permanent transects are relocated during each sampling period and are used to obtain a better statistical representation of the tree and shrub strata in each vegetation type, both on and off the tract, than would be possible using only permanent transects. The herbaceous stratum of the non-permanent transects is not sampled. Permanent vegetation transect locations are shown in Figure 2.3-1.

Plant specimens collected during each vegetation sampling period are field identified, tagged, coded for location and placed in plastic bags. This information in addition to number, date and collector is recorded in a field log book daily. All plant specimens are then routed to the laboratory where they are identified or verified to the species level.

2.3.1.3 Results

Ten different vegetation types in 89 separate locations were sampled on or near Tract C-a during late May and early June, and again in late July, 1975. Sixty-two transects were established during the May-June sampling period, of which 35 were designated as permanent. Permanent transect locations are shown in Figure 2.3-1. During July, the permanent transects were resampled only for the herbaceous stratum and shrub and tree strata were sampled on a total of 27 non-permanent transects in the ten vegetation types. Permanent and non-permanent transect data were combined for each sampling period to provide a regional view of the phytosociological characteristics common to each vegetation type. A list of the plant species encountered on the study area to date is included in Table 2.3-1.

The flora identified to date in the Tract C-a study area includes 5 species of trees, 36 species of shrubs and 201 herbaceous species, of which 41 species are classified as grasses and/or grass-like plants (Table 2.3-1). Three species included in the flora require special notation. Astragalus lutosus, a milkvetch, is on the Smithsonian Institution

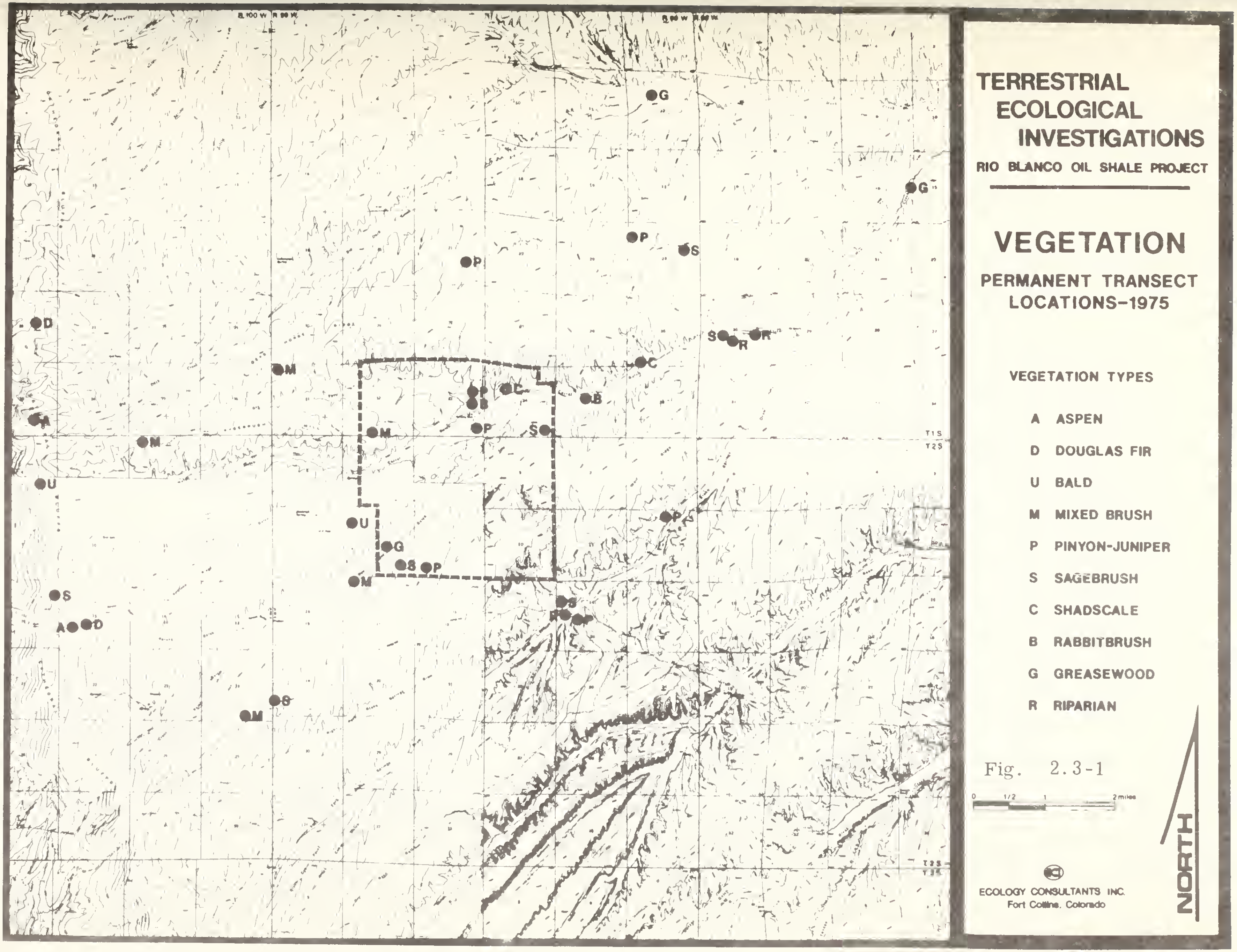TERRESTRIAL
ECOLOGICAL
INVESTIGATIONS
RIO BLANCO OIL SHALE PROJECT
VEGETATION
PERMANENT TRANSECT
LOCATIONS-1975
VEGETATION TYPES
A ASPEN
D DOUGLAS FIR
U BALD
M MIXED BRUSH
P PINYON-JUNIPER
S SAGEBRUSH
C SHADSCALE
B RABBITBRUSH
G GREASEWOOD
R RIPARIAN
0
1/2
1
2 miles
NORTH
ECOLOGY CONSULTANTS INC.
Fort Collins, Colorado
T1S
T2S

Fig. 2.3-1

Table 2.3-1. Species of plants observed to date in the vicinity of Tract C-a for RBOSP*

Abbrev.	Species
	TREES
Juos[1/]	*Juniperus osteosperma* (Torr.) Little;[2/](Pinaceae),[3/]Phan,[4/] Utah juniper, (V) 5/
Pied	*Pinus edulis* Engelm.; (Pinaceae), Phan, pinyon pine
Poan	*Populus angustifolia* James; (Salicaceae), Phan, narrowleaf cottonwood, (V)
Potr	*Populus tremuloides* Michx.; (Salicaceae), Phan, quaking aspen
Psme	*Pseudotsuga menziesii* (Mirbel) Franco; (Pinaceae), Phan, Douglas fir
	SHRUBS
Acgl	*Acer glabrum* Torr.; (Aceraceae), Phan, Rocky Mountain maple, (V)
AMELA	*Amelanchier* sp.
Amal	*Amelanchier alnifolia* Nutt.; (Rosaceae), Phan, Saskatoon serviceberry, (V)
Amut	*Amelanchier utahensis* Koehne; (Rosaceae), Phan, Utah serviceberry, (V)
Arfr	*Artemisia frigida* Willd.; (Compositae), Cham, fringed sagebrush, (V)
Artr	*Artemisia tridentata* Nutt.; (Compositae), Phan, Cham, big sagebrush, (V)
Atca	*Atriplex canescens* (Pursh) Nutt.; (Chenopodiaceae) Cham, fourwing saltbush, (V)
Atco	*Atriplex confertifolia* (Torr. & Fremont) S. Wats.; (Chenopodiaceae), Cham, shadscale, (V)

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* Key to footnotes appears at the end of the species list.

Table 2.3-1. (Continued)

Abbrev.	Species
	SHRUBS (Cont.)
	Berberis repens; See *Mahonia repens*
Befo	*Betula fontinalis* Sarg.; (Betulaceae), Phan, water birch (V)
	Betula occidentalis; See *Betula fontinalis*
Cema	*Ceanothus martini* M.E. Jones; (Rhamnaceae), Cham, Martin ceanothus, (V)
Cemo	*Cercocarpus montanus* Raf.; (Rosaceae), Phan, true mountain mahogany, (V)
CHRYS	*Chrysothamnus* sp.
Chde	*Chrysothamnus depressus* Nutt.; (Compisitae), Cham, dwarf rabbitbrush
Chna	*Chrysothamnus nauseosus* (Pall.) Britt. in Britt. & Brown; (Compositae), Phan, rubber rabbitbrush, (V)
Chvi	*Chrysothamnus viscidiflorus* (Hook.) Nutt.; (Compositae), Cham, Douglas rabbitbrush, (V)
	Cornus stolonifera; See *Swida sericea*
Epvi	*Ephedra viridis* Coville; (Ephedraceae), Cham, green ephedra
Eula	*Eurotia lanata* (Pursh) Moquin; (Chenopodiaceae), Cham, common winterfat, (V)
Gusa	*Gutierrezia sarothrae* (Pursh) Britt. & Rusby; (Compositae), Cham, broom snakeweed
Hodu	*Holodiscus dumosus* (Nutt.) Heller; (Rosaceae), Cham, bush ocean-spray, (V)
Mare	*Mahonia repens* (Lindl.) G. Don; (Berberidaceae), Cham, creeping barberry, (V)
Opfr	*Opuntia fragilis* (Nutt.) Haw.; (Cactaceae), Succ, brittle pricklypear

Table 2.3-1. (Continued)

Abbrev.	Species
	SHRUBS (Cont.)
Oppo	*Opuntia polyacantha* Haw.; (Cactaceae), Succ, plains pricklypear
Pamy	*Pachystima myrsinites* (Pursh) Raf.; (Celastraceae), Cham, myrtle pachystima (V)
Puvim	*Prunus virginiana* var. *melanocarpa* (A. Nels.) Sarg.; (Rosaceae), Phan, black common chokecherry
Putr	*Purshia tridentata* (Pursh) D.C.; (Rosaceae), Cham, antelope bitterbrush, (V)
Quga	*Quercus gambelii* Nutt.; (Fagaceae), Phan, Gambel oak, (V)
RIBES	*Ribes* sp.
Riau	*Ribes aureum* Pursh; (Saxifragaceae), Cham, golden current, (V)
Rice	*Ribes cereum* Dougl.; (Saxifragaceae), Cham, wax current, (V)
Riin	*Ribes inerme* Rydb.; (Saxifragaceae), Cham, whitestem gooseberry, (V)
ROSA	*Rosa* sp.
Rowo	*Rosa woodsii* Lindl.; (Rosaceae), Cham, Wood's rose
Saex	*Salix exigua* Nutt.; (Salicaceae), Cham, willow, (V)
Sain	*Salix interior* Rowlee; (Salicaceae), Cham, willow, (V)
Saco	*Sambucus coerulea* Raf.; (Caprifoliaceae), Cham, blueberry elder, (V)
Save	*Sarcobatus vermiculatus* (Hook.) Torr.; (Chenopodiaceae), Cham, black greasewood, (V)
Sosc	*Sorbus scopulina* Greene; (Rosaceae), Cham, Greenes mountain-ash, (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	SHRUBS (Cont.)
Swse	*Swida sericea* (L.) Holub; (Cornaceae), Cham, redosier dogwood, (V)
Syor	*Symphoricarpos oreophilus* A. Gray; (Caprifoliaceae), Cham, mountain snowberry (V)
Teca	*Tetradymia canescens* D.C.; (Compositae), Cham, gray horsebrush, (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE)
Acla	*Achillea lanulosa* Nutt.; (Compositae) Hemi, western yarrow, (N)[6] (V)
Agur	*Agastache urticifolia* Kuntze; (Labiatae), Hemi, nettleleaf giant-hyssop, (N) (V)
AGOSE	*Agoseris* sp.
Agau	*Agoseris aurantiaca* (Hook.) Greene; (Compositae) Hemi, orange agoseris, (N) (V)
Aggl	*Agoseris glauca* (Pursh) Raf.; (Compositae), Hemi, pale agoseris, (N) (V)
Alte 2	*Allium textile* Nels. & Macbr.; (Liliaceae), Cryp, textile onion, (N) (V)
AMBRO	*Ambrosia* sp. (L.); (Compositae) Ther, ragweed, (N)
Anse	*Androsace septentrionalis* L.; (Primulaceae), Ther, rock-jasmine, (N) (V)
ANGEL	*Angelica* sp.
Anam	*Angelica ampla* A. Nels; (Umbelliferae), Hemi, Angelica, (N) (V)
Anpi	*Angelica pinnata* S. Wats; (Umbelliferae), Hemi, small-leaf angelica, (N) (V)
ANTEN	*Antennaria* sp.
Anmi	*Antennaria microphylla* Rydb.; (Compositae), dioecious, Hemi, pussytoes, (N) (V)
Anpu	*Antennaria pulcherrima* (Hook.) Greene; (Compositae), dioecious, Hemi, showy pussytoes, (N) (V)
Anro	*Antennaria rosea* Greene; (Compositae), dioecious, Hemi, rose pussytoes (N) (V)
Aqba	*Aquilegia barnebyl* Munz; (Ranunculaceae), Hemi, columbine, (Rare--endemic to Green River shale deposits), (N) (V)

Table 2.3- 1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Aqca	*Aquilegia caerulea* James; (Ranun culaceae), Hemi, Colorado columbine, (Protected by Colorado State Law) (N) (V)
ARABI	*Arabis* sp.
Ardi 3	*Arabis divaricarpa* A. Nels.; (Cruciferae), Hemi, rockcress, (N) (V)
Ardr	*Arabis drummondi* A. Gray; (Cruciferae), Hemi, Drummond rockcress, (N) (V)
Arfe 4	*Arabis fendleri* (Wats.) Greene; (Cruciferae), Hemi Fendler rockcress, (N) (V)
Arfes	*Arabis fendler* var. *spatifolia* (Rydb.) Rollins; (Cruciferae), Hemi, rockcress, (N) (V)
ARENA	*Arenaria* sp.
Area	*Arenaria eastwoodiae* Rydb.; (Caryophyllaceae), Hemi, Sandwort, (N) (V)
Arfe	*Arenaria fendleri* A. Gray; (Caryophyllaceae), Hemi, Fendler Sandwort, (N) (V)
ARTEM	*Artemisia* sp.
Ardr	*Artemisia dracunculus* L.; (Compositae), Hemi, Tarragon, (N) (V)
Arlu	*Artemisia ludoviciana* Nutt.; (Compositae), Hemi, Louisiana sagebrush, (N) (V)
Ascr	*Asclepias cryptoceras* S. Wats.; (Asclepidaceae), Hemi, milkweed, (N) (V)
ASTER	*Aster* sp.
Asar 6	*Aster arenosus* Blake; (Compositae), Hemi, aster, (N) (V)
ASTRA	*Astragalus* sp.
Asch	*Astragalus chamaeleuce* A. Gray; (Leguminosae), Hemi, milkvetch, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Asdi	*Astragalus diversifolius* A. Gray; (Leguminosae), Hemi, milkvetch, (N) (V)
Aslu	*Astragalus lutosus* M.E. Jones; (Leguminosae), Hemi, milkvetch, (threatened and endangered--endemic to Green River shale deposits), (N) (V)
Aspu	*Astragalus purshii* Dougl. ex. Hook; (Leguminosae), Hemi, Pursh locoweed, (N) (V)
Assp 3	*Astragalus spatulatus* Sheld.; (Leguminosae), Hemi, tufted milkvetch, (N) (V)
Aste 3	*Astragalus tenellus* Pursh; (Leguminosae), Hemi, loose flower milkvetch, (N) (V)
Basa	*Balsamorhiza sagittata* (Pursh) Nutt.; (Compositae), Hemi, arrowleaf balsam root, (N) (V)
BORAG	*Boraginaceae*
CALOC	*Calochortus* sp.
Canu	*Calochortus nuttallii* Torr.; (Liliaceae), Cryp, segolily mariposa, (N) (V)
Cagu	*Calochortus gunnisonii* S. Wats.; (Liliaceae), Cryp, (N)
Cabu	*Capsella bursa-pastoris* (L.) Medic.; (Cruciferae), Ther, shepherds-purse, (I)
Cach 3	*Castilleja chromosa* A. Nels.; (Scropholariaceae), Hemi, Indian paintbrush, (N) (V)
Cali	*Castilleja linariaefolia* Benthin D.C.; (Scrophulariaceae), Hemi, Wyoming painted cup (N) (V)
CHAEN	*Chaenactis* sp.
Chdo	*Chaenactis douglasii* (Hook) Hook & Arn.; (Compositae), Hemi, Douglas chaenactis, (N) (V)
CHENO	*Chenopodium* sp.

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Chal	*Chenopodium album* L.; (Chenopodiaceae), Ther, Lambsquarter goosefoot, (I) (V)
Chfr 2	*Chenopodium fremontii* S. Wats.; (Chenopodiaceae), Ther, Fremont goosefoot, (N) (V)
	Chenopodium gigantospermum; See *Chenopodium hybridum*
Chgi	*Chenopodium hybridum* (L.): (Chenopodiaceae), Ther, mapleleaf goosefoot, (origin uncertain), (V)
Chle	*Chenopodium leptophyllum* Nutt.; (Chenopodiaceae), Ther, slimleaf goosefoot, (N) (V)
Chte	*Chorispora tenella* D.C.; (Cruciferae), Ther, chorispora, (I) (V)
CIRSI	*Cirsium* sp.
Ciar 2	*Cirsium arvense* (L.) Scop.; (Compositae), Hemi, Canada thistle, (I) (V)
	Cirsium lanceolatum; See *Cirsium vulgare*
Ciun	*Cirsium undulatum* (Nutt.) Spreng.; (Compositae), Hemi, wavyleaf thistle, (N) (V)
Civu	*Cirsium vulgare* (Savi) Tenore; (Compositae), Hemi, bull thistle, (I) (V)
Clco	*Clematis columbiana* (Nutt.) T.& G.; (Ranuncularceae), Hemi, (N)
Clhi	*Clematis hirsutissima* Pursh; (Ranunculaceae), Hemi, Douglas clematic, (N) (V)
Clps	*Clematis pseudoalpina* (Kuntze) A. Nels. in Coult. & Nels; (Ranunculaceae), Hemi, (N) (V)
Copa 2	*Collinsia parviflora* Dougl. in Lindl.; (Scrophulariaceae), Ther, little flower collinsia, (N) (V)
Coli	*Collomia linearis* Nutt.; (Polemoniaceae), Ther, slenderleaf collomia, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Copa	*Comandra umbellata* ssp. *pallida* (A. DC.) Piehl; (Santalaceae), Hemi, bastard toadflax, (N) (V)
COMPO	Compositae
Coau	*Corydalis aurea* Willd.; (Fumariaceae), Ther, golden corydalis, (N) (V)
CREPI	*Crepis* sp.
Crac	*Crepis acuminata* Nutt.; (Compositae), Hemi, tapertip hawksbeard, (N) (V)
Croc	*Crepis occidentalis* Nutt.; (Compisitae), Hemi, western hawksbeard, (N) (V)
CRUCI	Cruciferae
CRYPT	*Cryptantha* sp.
Crse	*Cryptantha sericea* (A. Gray) Payson; (Boraginaceae), Hemi, (N) (V)
CYMOP	*Cymopterus* sp.
Cyac	*Cymopterus acaulis* (Pursh) Raf.; (Umbellifereae), Cryp, (N) (V)
Cyfe	*Cymopterus fendleri* A. Gray; (Umbellifereae), Cryp, Chimaya, (N) (V)
DELPH	*Delphinium* sp.
Dene	*Delphinium nelsonii* Greene; (Ranunculaceae), Hemi, Menzies larkspur, (N) (V)
DESCU	*Descurainia* sp.
Depi	*Descurainia pinnata* (Walt.) Britt; (Cruciferae), Ther, pinnate tanseymustard, (N)
Deri	*Descurainia richardsonii* (Sweet) O.E. Schulz; (Cruciferae), Ther, Richardson tanseymustard, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Epad	*Epilobium adenocaulon* Hausskn.; (Onograceae), Hemi, sticky willowweed, (N) (V)
EQUIS	*Equisetum* sp.
Eqla	*Equisetum laevigatum* A. Br.; (Equisetaceae), Cryp, smooth horsetail, (N) (V)
ERIGE	*Erigeron* sp.
Erea	*Erigeron eatonii* A. Gray; (Compositae), Hemi, Eaton fleabane, (N) (V)
Erpu 2	*Erigeron pumilus* Nutt.; (Compositae), Hemi, low fleabane, (N) (V)
Ersp	*Erigeron speciosus* (Lindl.) DC.; (Compositae), Hemi, Oregon fleabane
ERIOG	*Eriogonum* sp.
Eral	*Eriogonum alatum* Torr.; (Polygonaceae), Hemi, wing eriogonum, (N) (V)
Ervi	*Eriogonum densum* Greene; (Polygonaceae), Hemi, broom eriogonum, (N) (V)
Erlo	*Eriogonum lonchophyllum* T. & G.; (Polygonaceae), Hemi, eriogonum, (N) (V)
Erov	*Eriogonum ovalifolium* Nutt.; (Polygonaceae), Hemi, cushion eriogonum, (N) (V)
Erum	*Eriogonum umbellatum* Nutt.; (Polygonaceae), Hemi, sulfur eriogonum, (N) (V)
Erar 6	*Erysimum asperum* (Nutt.) DC.; (Polygonaceae), Hemi, plains erysimum, (N) (V)
EUPHO	*Euphorbia* sp.
Eufe	*Euphorbia fendleri* T. & G.; (Euphorbiaceae), Hemi, Fendler euphorbia, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Euro	*Euphorbia robusta* (Engelm.) Small; (Euphorbiaceae), Heml, robust euphorbia, (N) (V)
FRAGA	*Fragaria* sp.
Frsp	*Frasera speciosa* Douglas; (Gentianaceae), Hemi, showy frasera, (N) (V)
Frat	*Fritillaria atropurpurea* Nutt.; (Liliaceae), Cryp, purplespot fritillaria, (N) (V)
Gabo	*Galium boreale* L.; (Rubiaceae), Hemi, northern bedstraw, (N) (V)
Geri	*Geranium richardsonii* Fisch. & Trautv.; (Geraniaceae), Hemi, Richardson geranium, (N) (V)
	Gilia spp.; See *Ipomopsis* spp.
Hafl	*Hackelia floribunda* (Lehm.) Johnston; (Boraginaceae), Hemi, stickseed, (N) (V)
HAPLO	*Haplopappus* sp.
Haac	*Haplopappus acaulis* (Nutt.) A. Gray; (Compositae), Hemi, stemless goldenweed, (N) (V)
Hanu	*Haplopappus nuttallii* T. & G.; (Compositae), Hemi, goldenweed, (N) (V)
HEDYS	*Hedysarum* sp.
Hebo	*Hedysarum boreale* Nutt.; (Leguminosae), Hemi, northern sweetvetch, (N) (V)
Heun	*Helianthella uniflora* (Nutt.) T.& G.; (Compositae), Hemi, oneflower helianthella, (N) (V)
Hela	*Heracleum lanatum* Michx.; (Umbellifereae) Hemi, common cowparsnip, (N) (V)
Hepa	*Heuchera parviflora* Nutt. ex. T. & G.; (Saxifragaceae), Hemi, littleleaf alumroot, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Hyfi	*Hymenopappus filifolius* Hook.; (Compositae), Hemi, fineleaf hymenopappus, (N) (V)
HYMEN	*Hymenoxys* sp.
Hyac	*Hymenoxys acaulis* (Pursh) Parker; (Compositae), Hemi, stemless hymenoxys, (N) (V)
Ipag	*Ipomopsis aggregata* (Pursh) V. Grant; (Polemoniaceae), Hemi, skyrocket gilia, (N) (V)
Ipco	*Ipomopsis congesta* (Hook.) V. Grant; (Polemoniaceae), Hemi, ballhead gilia, (N) (V)
KOCHI	*Kochia* sp.
Koir	*Kochia iranica* Bornm.; (Chenopodiaceae), Ther, summer cypress, (I)
	Kochia scoparia; See *Kochia iranica*
LACTU	*Lactuca* sp.
Lase	*Lactuca serriola* L.; (Compositae), Ther, prickly lettuce, (I)
LAPPU	*Lappula* sp.
Lare	*Lappula redowskii* (Hornem.) Greene; (Boraginaceae), Ther, annual stickseed, (N) (V)
LEPID	*Lepidium* sp.
Lemo	*Lepidium montanum* Nutt.; (Cruciferae), Hemi, pepperweed, (N) (V)
Lepe	*Lepidium perfoliatum* L.; (Cruciferae), Ther, clasping pepperweed, (I) (V)
Lepu	*Leptodactylon pungens* (Torr.) Rydb.; (Polemoniaceae), Hemi, (N) (V)
Lipo	*Ligusticum porteri* C. & R.; (Umbellifereae), Hemi, Porter ligusticum, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Liki	*Linum kingii* Wats. in King; (Linaceae), Hemi, flax, (N) (V)
Lile	*Linum lewisii* Pursh; (Linaceae), Hemi, Lewis flax, (N) (V)
LITHO	*Lithospermum* sp.
Liin	*Lithospermum incisum* Lehm.; (Boraginaceae), Hemi, gromwell, (N) (V)
Liru	*Lithospermum ruderale* Dougl. in Lehm.; (Boraginaceae), Hemi, (N) (V)
LOMAT	*Lomatium* sp.
Logr	*Lomatium grayi* C. & R.; (Umbellifereae), Cryp, desert parsley, (N) (V)
Loju	*Lomatium juniperinum* (M.E. Jones) C. & R.; (Umbellifereae), Cryp, desert parsley, (N) (V)
Loor	*Lomatium orientale* C. & R.; (Umbellifereae), Cryp, desert parsley, (N) (V)
LUPIN	*Lupinus* sp.
Luar	*Lupinus argenteus* Pursh; (Leguminosae), Hemi, silvery lupine, (N) (V)
Luca	*Lupinus caudatus* Kellogg; (Leguminosae), Hemi, tailcup lupine, (N) (V)
Lyju	*Lygodesmia juncea* (Pursh) D. Don.; Hemi, rush skeletonplant, (N) (V)
MALVA	*Malva* sp.; (Malvaceae), Hemi, mallow (N)
Mear	*Mentha arvense* L.; (Labiateae), Hemi, field mint, (N) (V)
MENTZ	*Mentzelia* sp.
Meal 2	*Mentzelia albicaulis* Dougl. ex Hook.; (Loasaceae), Ther, whitestem mentzelia, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Memu	*Mentzelia multiflora* (Nutt.) Gray; (Loasaceae), Hemi, desert mentzelia, (N) (V)
MERTE	*Mertensia* sp.
Meci	*Mertensia ciliata* (James) G. Don; (Boraginaceae), Hemi, mountain bluebells, (N) (V)
Mopa	*Moldavica parviflora* (Nutt.) Britton; (Labiateae), Ther, American dragonhead, (N) (V)
MOSS	Moss
Oeca	*Oenothera caespitosa* Nutt.; (Onograceae), Hemi, tufted evening-primrose, (N) (V)
Oeco	*Oenothera coronopifolia* T. & G.; (Onograceae), Hemi, evening primrose, (N) (V)
Oela	*Oenothera lavandulaefolia* T. & G.; (Onograceae), Hemi, lavanderleaf evening-primrose, (N) (V)
OSMOR	*Osmorhiza* sp.
Osde	*Osmorhiza depauperata* Phil.; (Umbellifereae), Hemi, sweetroot, (N) (V)
Oxla	*Oxytropis lambertii* var. *bigelovii* A. Gray; (Leguminosae), Hemi, Lambert crazyweed, (N) (V)
PENST	*Penstemon* sp.
Peca	*Penstemon caespitosus* Nutt. ex A. Gray; (Scrophulariaceae), Hemi, mat penstemon, (N) (V)
Pefr	*Penstemon fremontii* T. & G.; (Scrophulariaceae), Hemi, beardtongue, (N) (V)
Peos	*Penstemon osterhoutii* Pennell; (Scrophulariaceae), Hemi, beardtongue, (N) (V)
Pest	*Penstemon strictus* Benth. in DC.; (Scrophulariaceae), Hemi, Rocky Mountain penstemon, (N) (V)
Phse	*Phacelia sericea* (Graham) A. Gray; (Hydrophyllaceae), Hemi, silky phacelia, (N) (V)
PHLOX	*Phlox* sp.

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Phho	*Phlox hoodii* Rich.; (Polemoniaceae), Hemi, Hoods phlox, (N) (V)
Phlo	*Phlox longifolia* Nutt.; (Polemoniaceae), Hemi, longleaf phlox, (N) (V)
Phmu	*Phlox multiflora* A. Nels.; (Polemoniaceae), Hemi, flowery phlox, (N) (V)
Phfl	*Physaria floribunda* Rydb.; (Cruciferae), Hemi, twinpod, (N) (V)
PLANT	*Plantago* sp.; (Plantaginaceae), Ther, plantain, (N)
Posa 3	*Polygonum sawatchense* Small; (Polygonaceae), Ther, knotweed, (N) (V)
POTEN	*Potentilla* sp.
Pomo	*Potentilla monspeliensis* L.; (Rosaceae), Ther, cinquefoil, (origin uncertain) (V)
Popu	*Potentilla pulcherrima* Lehm.; (Rosaceae), Hemi, cinquefoil, (N) (V)
Poqu	*Potentilla quinquifolia* Rydb.; (Rosaceae), Hemi, cinquefoil, (N) (V)
Pyas	*Pyrola asarifolia* Michx.; (Ericaceae), Hemi, alpine pyrola, (N) (V)
RANUN	*Ranunculus* sp.
Racy	*Ranunculus cymbalaria* var. *saximontanus* Fernald; (Ranunculaceae), Hemi, Rocky Mountain buttercup, (N) (V)
Rasc 2	*Ranunculus sceleratus* L.; (Ranunculaceae), Hemi, blister buttercup, (I) (V)
RORIP	*Rorippa* sp.
Rona	*Rorippa nasturtium-aquaticum* (L.) Schinz & Thell.; (Cruciferae), Hemi, watercress, (I) (V)
Rucr	*Rumex crispus* L.; (Polygonaceae), Hemi, curlydock (N) (V)

Table 2.3- 1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
Ruut	*Rumex utahensis* Rech. f.; (Polygonaceae), Hemi, dock, (N) (V)
Saka	*Salsola kali* L.; (Chenopodiaceae), Ther, Russianthistle, (I) (V)
Scla	*Scrophularia lanceolata* Pursh, (Scrophulariaceae), Hemi, lanceleaf figwort, (N) (V)
SENEC	*Senecio* sp.
Sein	*Senecio integerrimus* Nutt.; (Compositae), Hemi, lambstongue groundsel, (N) (V)
Semu 2	*Senecio mutilobatus* T. &. G. ex A. Gray; (Compositae), Hemi, lobeleaf groundsel, (N) (V)
SISYM	*Sisymbrium* sp.
Sial	*Sisymbrium altissimum* L.; (Cruciferae), Ther, tumblemustard, (I) (V)
Sili	*Sisymbrium linifolium* Nutt. in T. & G.; (Cruciferae), Hemi, tumblemustard, (N) (V)
SMILA	*Smilacina* sp.
Smra	*Smilacina racemosa* var. *amplexicaulis* (Nutt.) S. Wats.; (Liliaceae), Cryp, Solomon-plume, (N) (V)
Smst	*Smilacina stellata* (L.) Desf.; (Liliaceae), Cryp, Solomon-plume, (N) (V)
SOLID	*Solidago* sp.; (Compositae), Hemi, goldenrod, (N) (V)
SPHAE	*Sphaeralcea* sp.
Spco	*Sphaeralcea coccinea* (Pursh) Rydb.; (Malvaceae), Hemi, scarlet globemallow, (N) (V)
Stpi 2	*Stanleya pinnata* (Pursh) Britton; (Cruciferae), Hemi, desert princesplume, (N) (V)
Stco 3	*Streptanthus cordatus* Nutt. ex T. & G.; (Cruciferae), Hemi, heartleaf twistflower, (N) (V)

Table 2.3- 1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE) (Cont.)
TARAX	*Taraxacum* sp.
Taof	*Taraxacum officinale* Web. in Wiggers; (Compositae), Hemi, common dandelion, (distribution worldwide) (V)
Thfe	*Thalictrum fendleri* Engelm. ex A. Gray; (Ranunculaceae), Hemi, Fendler meadowrue, (N) (V)
Thmo	*Thermopsis montana* Nutt. ex T. & G.; (Leguminoseae), Hemi, mountain thermopsis, (N) (V)
Toin	*Townsendia incana* Nutt.; (Compositae), Hemi, hoary townsendia, (N) (V)
TRIFO	*Trifolium* sp.
Trgy	*Trifolium gymnocarpon* Nutt.; (Leguminoseae), Hemi, hollyleaf clover, (N) (V)
UMBEL	Umbelliferae
Urdig	*Urtica dioica* ssp. *gracilis* (A.T.) Selander; (Labiateae), Hemi or Ther, big stinging nettle, (N)
Vaoc	*Valeriana occidentalis* Heller; (Valerianaceae), Hemi, western valerian, (N) (V)
Viam	*Vicia americana* Muehl. ex Willd.; (Leguminoseae), Hemi, American vetch, (N) (V)
Viad	*Viola adunca* Smith; (Violaceae), Hemi, Hook violet, (N) (V)
Vicar	*Viola canadensis* L. var. *rugulosa* (Greene) C.L. Hitchcock; (Violaceae), Hemi, Canada violet, (N) (V)
Vinu	*Viola nuttallii* Pursh; (Violaceae), Hemi, Nuttall violet, (N) (V)
Vipa 2	*Viola pallens* (Banks) Brainerd; (Violaceae), Hemi, marsh violet, (N) (V)
	Viola palustris ssp. *brevipes*; See *Viola pallens*

Table 2.3-1. (Continued)

Abbrev.	Species
	HERBACEOUS (NON-GRASSLIKE (Cont.)
	Viola rugulosa; See *Viola canadensis* var. *rugulosa*
Zyveg	*Zygadenus venenosus* var. *gramineus* (Rydb.) Walsh ex M.E. Peck; (Liliaceae), Cryp, grassy deathcamas, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	GRASSES AND GRASS-LIKES
AGROP	*Agropyron* sp.
	Agropyron cristatum; See *Agropyron desertorum*
Agde 2	*Agropyron desertorum* (Risch.) Schult.; (Gramineae), Hemi, crested wheatgrass, (I) (N)
	Agropyron inerme; See *Agropyron spicatum* var. *inerme*
Agre 2	*Agropyron repens* (L.) Beauv.; (Gramineae), Hemi, quackgrass, (I) (V)
Agsm	*Agropyron smithii* Rydb.; (Gramineae), Bluestem wheatgrass, (N) (V)
Agspi	*Agropyron spicatum* (Pursh) Scribn. & Smith var. *inerme* Heller; (Gramineae), Hemi, beardless bluebunch wheatgrass, (N) (V)
Agsp	*Agropyron spicatum* (Pursh) Scribn. & Smith var. *spicatum*; (Gramineae), Hemi, bearded bluebunch wheatgrass, (N) (V)
Agsu	*Agropyron subsecundum* (Link) Hitchc.; (Gramineae), bearded wheatgrass, (N) (V)
Agtr	*Agropyron trachycaulum* (Link) Richt; (Gramineae), Hemi, slender wheatgrass, (N) (V)
Bogr	*Bouteloua gracilis* (H.B.K.) Lag.; (Gramineae), Hemi, blue grama, (N) (V)
BROMU	*Bromus* sp.
Brin	*Bromus inermis* Leyss; (Gramineae), Hemi, smooth brome, (I) (V)
Brma	*Bromus marginatus* Nees; (Gramineae), Hemi, big mountain brome, (N) (V)
Brte	*Bromus tectorum* L.; (Gramineae), Ther, cheatgrass brome, (I) (V)
CAREX	*Carex* sp.

Table 2.3- 1. (Continued)

Abbrev.	Species
	GRASSES AND GRASS-LIKES (Cont.)
Cage	*Carex geyeri* Boott; (Cyperaceae), Cryp, elk sedge, (N) (V).
Cala 2	*Carex lanuginosa* Michx.; (Cyperaceae), Cryp, wooly sedge, (N) (V)
Cane 2	*Carex nebraskensis* Dewey; (Cyperaceae), Cryp, Nebraska sedge, (N) (V)
Cave 2	*Carex vernacula* L.H. Bailey; (Cyperaceae), Cryp, sedge, (N) (V)
Elma	*Eleocharis macrostachya* Britt.; (Cyperaceae), Cryp, common spikerush, (N) (V)
ELYMU	*Elymus* sp.
Elci	*Elymus cinereus* Scribn. & Merr.; (Gramineae), Hemi, great basin wildrye, (N) (V)
FESTU	*Festuca* sp.; (Gramineae), Hemi, fescue, (N)
Glst	*Glyceria striata* (Lam.) Hitchcock; (Gramineae), Hemi, fowl mannagrass, (N) (V)
HORDE	*Hordeum* sp.
Hobr	*Hordeum brachyantherum* Nevski; (Gramineae), Hemi, meadow barley, (N) (V)
Hoju	*Hordeum jubatum* L.; (Gramineae), Hemi, foxtail barley, (N) (V)
JUNCU	*Juncus* sp.
Juara	*Juncus arcticus* ssp. *ater* (Rydb.) Hulten; (Juncaginaceae), Cryp, wiregrass, (N) (V)
	Juncus balticus; See *Juncus arcticus* spp. *ater*
Jusa	*Juncus saximontanus* A. Nels.; (Juncaginaceae), Cryp, Rocky Mountain rush, (N) (V)
	Koeleria cristata; See *Koeleria gracilis*

Table 2.3- 1. (Continued)

Abbrev.	Species
	GRASSES AND GRASS-LIKES (Cont.)
Kogr	*Koeleria gracilis* Pres.; (Gramineae), Hemi, prairie junegrass
Orhy	*Oryzopsis hymenoides* (R. & S.) Ricker; (Gramineae), Hemi, Indian ricegrass, (N) (V)
POA	*Poa* sp.
Poag	*Poa agassizensis* Boivin & D. Loeve; (Gramineae), Hemi, blue grass, (N) (V)
Poam	*Poa ampla* Merr.; (Gramineae), Hemi, big bluegrass, (N) (V)
Poca	*Poa canby* (Scribn.) Piper; (Gramineae), Hemi, Canby bluegrass, (N) (V)
Poco	*Poa compressa* L.; (Gramineae), Hemi, Canada bluegrass, (N) (V)
Pofe	*Poa fendleriana* (Steud.) Vasey; (Gramineae), Hemi, mutton bluegrass, (N) (V)
	Poa interior; See *Poa nemoralis* var. *interior*
Ponei	*Poa nemoralis* L. var. *interior* (Rydb.) Butters & Abbe; (Gramineae), Hemi, interior bluegrass, (N) (V)
Popr	*Poa pratensis* L.; (Gramineae), Hemi, Kentucky bluegrass, (I) (V)
Posa	*Poa sandbergii* Vasey; (Gramineae), Hemi, Sandberg bluegrass, (N) (V)
	Poa secunda; See *Poa sandbergii*
Scac	*Scirpus acutus* Muehl. ex Bigelow; (Cyperaceae), Cryp, tule bulrush, (N) (V)
	Sitanion hystrix; See *Sitanion longifolium*
Silo	*Sitanion longifolium* J.G. Smith; (Gramineae), Hemi, squirreltail, (N) (V)
Spai	*Sporobolus airoides* (Torr.) Torr.; (Gramineae), Hemi, alkali sacaton, (N) (V)

Table 2.3-1. (Continued)

Abbrev.	Species
	GRASSES AND GRASS-LIKES (Cont.)
STIPA	*Stipa* sp.
Stco 2	*Stipa columbiana* Mocoun; (Gramineae), Hemi, subalpine needlegrass, (N) (V)
Stco	*Stipa comata* Trin. & Rupr.; (Gramineae), Hemi, needle-and-thread, (N) (V)
Trma 3	*Triglochin maritima* L.; (Juncaginaceae), Cryp, shore podgrass, (N)
Tyla	*Typha latifolia* L. (Typhaceae), Cryp, common cattail, (N)

FOOTNOTES

[1] Abbreviation of genus and species in a four letter code (Plummer et al., 1966).

[2] Author citation, nomenclatural authority cited after each species name and delineated by a semi colon.

[3] The family of plants a species belongs to in parenthesis.

[4] Lifeforms of Plants (Raunkiaer, 1934).

Phan - Phanerophyte; Perennating bud at least 0.25 m above soil surface.

Cham - Chamaephyte; Perennating bud between 0 and 0.25 m above soil surface.

Hemi - Hemicryptophyte; Perennating bud in soil surface.

Cryp - Cryptophyte; Perennating buds covered by soil or water.

Ther - Therophyte; Annual plants, perennating buds contained in seed.

Succ - Succulent; Stems enlarged; serve as water storage organ.

[5] (V) - Voucher specimen collected.

[6] Origin or herbaceous species.

(N) - Native to the North American Continent.

(I) - Introduced from outside the North American Continent.

threatened and endangered plant species list (Smithsonian Institution, 1975), and was located near Cottonwood Spring on Big Duck Creek. *Aquilegia barnebyi*, a columbine endemic to the Green River formation (Munz, 1949), was located near Cottonwood Spring on Big Duck Creek. *Aquilegia caerulea*, Colorado columbine (Harrington, 1964), is the state flower and was located in most of the aspen stands and some of the more mesic mixed brush stands near Cathedral Bluffs.

The Douglas fir type occurs in isolated stands on northerly slopes at high elevations in the study area. This type is dominated by one tree species, *Pseudotsuga menziesii*, which provides a ground cover of 40-70%, and occurs at densities of 0.44-0.51 per 10m^2. In stands with numerous openings, a diverse and often dense shrub layer develops, with a total cover of 39-40% and a density of 0.8 - 1.14 individuals per m^2. Abundant shrub species include *Symphoricarpos oreophilus* and *Amelanchier utahensis*. The herbaceous stratum is strongly dominated by a sedge, *Carex geyeri*. Herbaceous cover values of greater than 20% were recorded during summer sampling. *Carex geyeri* dominated the cover in the spring before emergence of forb species, and then shared dominance with a low shrub *Pachystima myrsinites* over the rest of the summer season.

The aspen type is situated primarily on north facing slopes at high elevations in the study area. The open canopy (33-38% total cover), consisting of *Populus tremuloides*, allows the penetration of light and moisture and permits the development of a dense and diverse shrub stratum (11 species, 62-114% cover, 0.61-3.5 individuals per m^2). Abundant shrub species include *Symphoricarpos oreophilus* and *Amelanchier utahensis*. The herbaceous cover fluctuated greatly over the growing season, ranging from 3% cover in the spring to 42% cover in the summer. *Carex geyeri* dominated this stratum in the spring and several forb species became more important during the summer.

The mixed brush type consists of a wide variety of shrubs and occupies a wide range of habitats. Mixed brush communities range from tall dense *Quercus gambelii* and *Amelanchier utahensis* stands at higher elevations to low-growing *Artemisia tridentata*, *Amelanchier utahensis*, and *Symphoricarpos oreophilus* stands on upland ridgetops, and to *Cercocarpus montanus* and *Amelanchier utahensis* stands on dry slopes.

The shrub stratum is usually two-layered with the upper layer dominated by *Quercus gambelii*, *Amelanchier utahensis*, *Cercocarpus montanus*, and *Prunus virginiana*. The lower layer is dominated by a mixture of *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Symphoricarpos oreophilus*, and *Purshia tridentata*. The shrub stratum provided a dense cover (40-77%), and high density (1.0-1.6 individuals per m^2). Herbaceous cover ranged from 5% in the spring to 15-20% in the summer. *Carex geyeri* was the dominant species over both spring and summer sampling periods.

The pinyon-juniper type occupies slopes and ridgetops over much of the central and eastern part of the study area. This type is dominated by two tree species, *Pinus edulis* and *Juniperus osteosperma*, which form open, low density stands (20-30% total cover, 0.25-0.30 individuals per 10m^2). Up to 15 shrub species may occur in this type, with *Artemisia tridentata* and *Amelanchier utahensis* frequently the dominant species. All shrub species together provide sparse cover (8-13%), and occur at low densities (0.33-0.41 individuals per m^2). Herbaceous cover is very sparse (2-6%). Dominant species both in spring and summer sampling periods were three grasses, *Agropyron trachycaulum*, *Poa sandbergii*, and *Oryzopsis hymenoides*. Grasses and sedges contributed over 60% of the total cover for both sampling periods.

The sagebrush type is the most widely distributed plant community on the study area, occurring on deeper soils along stream bottoms, and on upland areas which range from 6000 to 8500 feet in elevation. This type is dominated by one species, *Artemisia tridentata*, and to a lesser extent by *Symphoricarpos oreophilus* in sites at higher elevations. A diverse (16 species shrub stratum provides 30-40% cover, and occurs at densities of 1.2-1.9 individuals per m^2. Herbaceous cover is sparse (7-17% cover), but is comprised of the largest number of species recorded for any type sampled (more than 60). The dominant species was a grass (*Poa* sp.) for both sampling periods. Total cover increased slightly (10%) between spring and summer. Grasses and sedges contributed approximately half of the total cover during the summer quarter.

The bald type occupies the windswept ridges and slopes at higher elevations near Cathedral Bluffs. Both shrub and herbaceous strata are low-growing, giving a very uniform appearance to the type. The few (4-8) shrub species do not form a separate stratum but are part of the herbaceous stratum, providing cover of only 1%.

The herbaceous stratum was diverse (43-46 species), and provided a total cover of 9% in the spring and up to 22% in the summer. Dominant species are a mixture of grasses *Agropyron trachycaulum*, *Koeleria gracilis*, and forbs *Astragalus spatulatus*, *Penstemon caespitosus*, *Hymenoxys acaulis*, and *Haplopappus nuttallii*.

The shadscale type occurs primarily on south facing dry talus slopes along the lower drainages of the study area. The shrub stratum provides low cover (6-17%), and densities of 0.53-0.84 individuals per m^2. Dominant species are *Atriplex confertifolia*, *Artemisia tridentata*, and *Chrysothamnus* sp. *Sarcobatus vermiculatus* and *Atriplex canescens* are frequent on some slopes within the type possibly because of higher soil salinities at these sites. The herbaceous stratum is sparse and unvarying (1-3% cover), and consists of a grass *Oryzopsis hymenoides*, and several perennial forb species.

The greasewood type occupies the alluvial deposits in the lower drainages of the study area. It is dominated by *Sarcobatus vermiculatus*, *Artemisia tridentata*, and *Chrysothamnus nauseosus*. The shrub stratum consists of medium sized shrubs with a moderate cover (42-45%), and a low ephemeral herbaceous cover (5.29%). Nine out of a total of 15 herbaceous species were annuals, and were active only during spring and early summer when soils were moist. Frequently encountered species included *Bromus tectorum*, *Lappula redowskii*, and *Kochia iranica*.

The rabbitbrush type is a secondary successional stage which develops on disturbed *Artemisia tridentata* areas. In many areas dominated by *Chrysothamnus* sp. the charred stumps of *Artemisia tridentata* still remain. The rabbitbrush type is characterized by almost pure stands of *Chrysothamnus nauseosus* or *Chrysothamnus viscidiflorus*. The shrub stratum provides high cover (31-63%) and high shrub densities (0.59-1.92 individuals per m^2). The herbaceous stratum varied in cover from 26% during the spring to 44% during mid-summer. This stratum is strongly dominated by a grass *Elymus cinereus* and contains few species (13).

The riparian type is restricted to small seeps and springs along the intermittent streams crossing the study area. *Salix* and *Populus* species, characteristic of streamside communities in this region, are almost absent. Many springs in the study area have been developed as pastures for livestock, with the result that most shrub species have been removed and replaced by pasture and weedy grass species. The great heterogeneity of the sites sampled (due to varying degrees of disturbance) allows few comparisons among sampling periods. The shrub stratum provides cover ranging from 0 in pasture areas to 50% in hillside springs where *Salix interior* and *Betula fontinalis* are predominant. Herbaceous stratum cover is greater than 50% for all sampling periods, and is dominated by a sedge *Carex* sp., and perennial grasses *Agropyron repens* and *Poa pratensis*.

2.3.2 Grazing Exclosure

2.3.2.1 Objectives

The grazing exclosure extablished on Tract C-a is designed to demonstrate and monitor vegetation responses to the exclusion of particular groups of grazing or browsing herbivores.

The objective of the "photographic plots" situated in the vicinity of the grazing exclosure is to provide a visual record of change or lack of change in the vegetation cover.

2.3.2.2 Methods

An exclosure has been situated in the southwest quarter of Tract C-a. The exclosure encompasses 1.21 ha (3 A) measuring 190.9 x 63.6m (626 x 208.7 ft) (Figure 2.3-2). The exclosure contains three compartments or sections, constructed to prevent access by particular groups of herbivores. The largest compartment contains 0.61 ha (1.5 A) and excludes domestic livestock and wild horses but allows free access to big game able to leap the fence and small wildlife that can enter through or under the wire. The second compartment, encloses 0.4 ha (1 A) and excludes big game and livestock, but not smaller mammals. The third compartment, 0.2 has (0.5 A) in size, is designed to prevent entry by all mammalian herbivores.

In addition to the three compartments within the exclosure, a control of "non-treatment" plot subjected to normal foraging pressures is established outside the exclosure.

Different sampling techniques are implemented for each of the three principal strata of the plant community. The grass-forb stratum is sampled by a combined ocular estimate - clipped plot method (adapted from National Academy of Sciences - National Research Council, 1962) on a permanent grid. The shrub stratum is sampled qualitatively by .004 ha circular plots. Data gathered within these plots include shrub species, maximum shrub height, mean crown diameter, percent of the canopy that is alive, and percent of the plant available to the potential browsing animal. The tree stratum is sampled by measuring the tree canopy intercepting a line which traces the perimeter of the established grass-forb grid.

At the exclosure, up to three individual shrubs of the major browse species are selected and permanently marked for photographic documentation in each sample grid. A white-painted plywood sheet marked with a one-inch grid of black lines and cut in two and hinged to facilitate handling, is used as a backdrop for photographing each shrub.

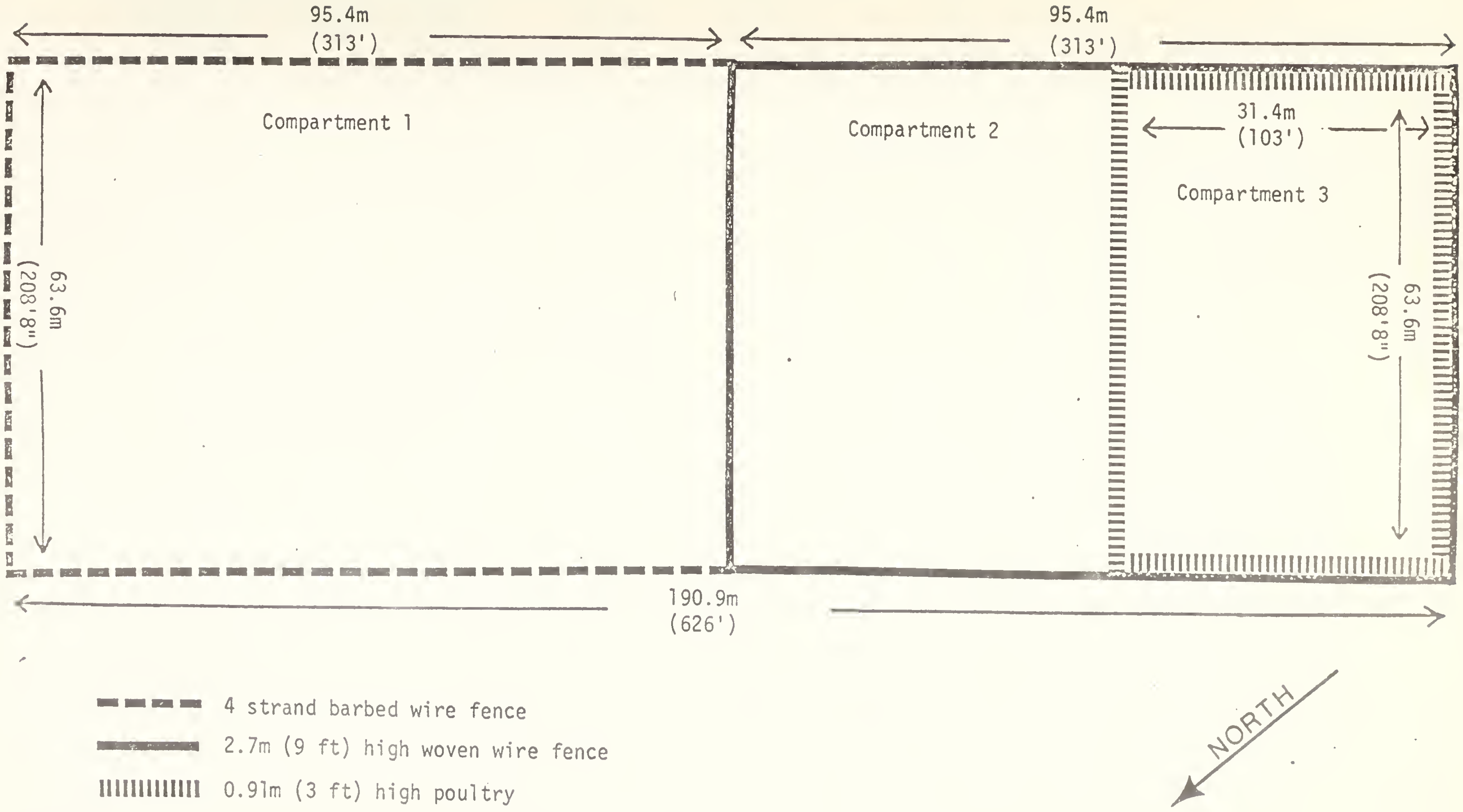

Figure 2.3-2. Design of the grazing exclosure used for RBOSP.

In the first season, photoplots are permanentaly located by driving rebar stakes at points directly below the camera and at corners of the backdrop sheet. In succeeding years, plots are relocated and rephotographed by use of those reference points. Photographs are taken each year and are timed to correlate with the important phenological stage of the shrubs in mid-summer, at the completion of twig elongation.

2.3.2.3 Results

Plant samples were collected in the exclosure and control area near the end of the reporting quarter and are presently being analyzed. Results will be reported in Progress Report 5.

Photoplot samples were collected near the end of the reporting quarter and are presently being analyzed. Results will be reported in Progress Report 5.

2.3.3 Small Mammals

2.3.3.1 Objectives

No change has occurred since Progress Report 2-Summary. See Section 2.3.3.1 in Progress Report 2-Summary for the objectives of the small mammal program.

2.3.3.2 Methods

No change has occured since Progress Report 3-Summary. See section 2.3.3.2 in Progress Report 3-Summary for the methods employed in the small mammal studies.

2.3.3.3 Results

A total of 580 individuals representing 12 species was captured during July small mammal live trapping operations. The species encountered are indicated in Table 2.3-2. The highest capture success occurred on grid 2, sagebrush, which accounted for 13.2 percent of the total individuals of all species trapped per 100 trap nights. Grids located in pinyon-juniper/sagebrush, pinyon-juniper (south slope) and pinyon-juniper (north slope) vegetation types also exhibited high capture success.

The highest Shannon-Weiner species diversity values were recorded for grids established in pinyon-juniper during July sampling (Table 2.3-3). The pinyon-juniper provides an additional stratum (the tree stratum) for small mammal nesting sites and refuge sites and results in the presence of more small mammal species.

Table 2.3-2. Species of wild mammals encountered to date in the vicinity of Tract C-a for RBOSP [1]

FAMILY Species	Common Name
SORICIDAE (Shrews)	
Sorex cinereus	Masked shrew
Sorex merriami (not previously recorded in the area)	Merriam's shrew
VESPERTILIONIDAE	
Myotis californicus	California myotis
Myotis sp.	
Myotis evotus	Long-eared myotis
Myotis subulatus	Small-footed myotis
Lasiurus cinereus	Hoary bat
LEPORIDAE (Hares and rabbits)	
Sylvilagus sp.	Cottontail
Lepus californicus	Black-tailed jackrabbit
Lepus townsendii	White-tailed jackrabbit
SCIURIDAE (Squirrels, ground squirrels, chipmunks)	
Eutamias minimus [4]	Least chipmunk
Eutamias quadrivittatus [4]	Colorado chipnunk
Spermophilus lateralis [4]	Golden-mantled ground squirrel
Spermophilus tridecemlineatus [4]	Thirteen-lined ground squirrel
Tamiasciurus hudsonicus	Red squirrel
GEOMYIDAE (Pocket gophers)	
Thomomys talpoides	Northern pocket gopher
HETEROMYIDAE (Pocket mice, kangaroo mice and kangaroo rats)	
Perognathus apache [4]	Apache pocket mouse
CRICETIDAE (New World mice and rats)	
Peromyscus maniculatus [4]	Deer mouse
Peromyscus truei [4]	Piñon mouse
Neotoma cinerea [4]	Bushy-tailed woodrat
Clethrionomys gapperi [4]	Gapper's red-backed vole

Table 2.3-2. (Continued)

FAMILY Species	Common Name
CRICETIDAE (Continued)	
Microtus montanus [4]	Montane vole
Microtus longicaudus [4]	Long-tailed vole
Lagurus curtatus [4]	Sagebrush vole
ERETHIZONTIDAE (Porcupines)	
Erethizon dorsatum	Porcupine
CANIDAE (Coyote, wolves and foxes)	
Canis latrans	Coyote
MUSTELIDAE (Mustelids, weasels, skunks)	
Mustela frenata	Longtailed weasel
Mustela erminea	Ermine
Taxidea taxus	Badger
FELIDAE (Cats)	
Lynx rufus	Bobcat
EQUIDAE (Horses) [2]	
Equus caballus	Feral horse
CERVIDAE (Deer and elk) [3]	
Cervus canadensis	Elk
Odocoileus hemionus	Mule deer

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[1] The following authority is used for small mammal nomenclature:

Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. Ronald Press Company, New York. 1162 pages.

[2] The following authority is used for feral horse nomenclature:

Blair, W.F., A.P. Blair, P. Brodkorb, F.R. Cagle and G.A. Moore. 1968. Vertebrates of the United States, second edition. McGraw-Hill Book Company. New York. 616 pages.

[3] The following authority is used for large mammal (except feral horse) nomenclature:

Lechleitner, R.R. 1969. Wild mammals of Colorado. Pruett Publishing Company, Boulder. 254 pages.

[4] Encountered during small mammal sample period 4, July 25-30, 1975.

Table 2.3-3. Shannon-Weiner diversity indices (H'), unbiased estimates of H' (E(H')), variance of H' (var (H')), maximum expected value of H' (H'(max)), and equitability (J) for all small mammal grids during sample period 4, July 25-30, 1975, for RBOSP

Grid Designation	Vegetation Type	H'	E(H')	var(H')	H'(max)	J
1	Bottomland meadow	0.500	0.400	0.061	0.693	0.722
2	Sagebrush	1.047	1.003	0.014	1.386	0.755
3	Rabbitbrush	0.619	0.571	0.034	1.099	0.563
4	Pinyon-juniper/mixed brush	1.038	0.992	0.006	1.099	0.945
5	Mixed brush	0.683	0.647	0.001	0.693	0.985
6	Pinyon-juniper/sagebrush	1.133	1.073	0.014	1.386	0.817
7	Upland meadow	0.520	0.484	0.020	0.693	0.750
A	Greasewood-sagebrush	1.040	1.022	0.004	1.386	0.750
B	Pinyon-juniper (south slope)	1.634	1.606	0.004	1.946	0.839
C	Pinyon-juniper (north slope)	1.477	1.452	0.004	1.792	0.825
D	Sagebrush	1.165	1.136	0.003	1.386	0.840
E	Mixed brush	1.137	1.110	0.007	1.609	0.706
F	Douglas fir	0.693	0.670	0.000	0.693	1.000
G	Aspen	0.613	0.563	0.033	1.099	0.558

The deer mouse and the least chipmunk were the most commonly encountered small mammal species in July. Both were encountered in all trapping grids except one and these species accounted for 39.6 and 34.2 percent of the total captures, respectively.

Fifteen of the seventeen adult females of three predominant small mammal species (least chipmunk, deer mouse and long-tailed vole) collected for investigation of reproductive effort in July were found to be reproductively active.

During July, 22 animals of the same three species were also collected for analysis of stomach contents. The least chipmunk and the deer mouse were found to be utilizing seeds almost exclusively while the long-tailed vole preferred succulent vegetation parts.

Ten individuals of three species were captured in pitfall traps in July. All three, the deer mouse, Apache pocket mouse, and the long-tailed vole have been documented by live trapping.

Two species of lagomorphs, the cottontail and white tailed jackrabbit, and the porcupine were encountered on night spotlight censuses in June. However, the paucity of data precludes formulation of firm conclusions concerning density and relative abundance at this time.

Five species of bats were captured by mist netting during June and August 1975. The long-eared myotis and small footed myotis were documented in June while the California myotis, hoary bat and an unidentified _Myotis_ sp. were collected during August.

2.3.4 Large Mammals

2.3.4.1 Objectives

No changes have been implemented since Progress Report 2-Summary. See section 2.3.4.1 in Progress Report 2-Summary for objectives of the large mammal studies.

2.3.4.2 Methods

Large mammals (mule deer, elk, feral horses, large predators, and domestic livestock) are censused along established transects with a fixed-wing aircraft to determine distribution and abundance. Large mammal aerial transects are shown in Figure 2.3-3.

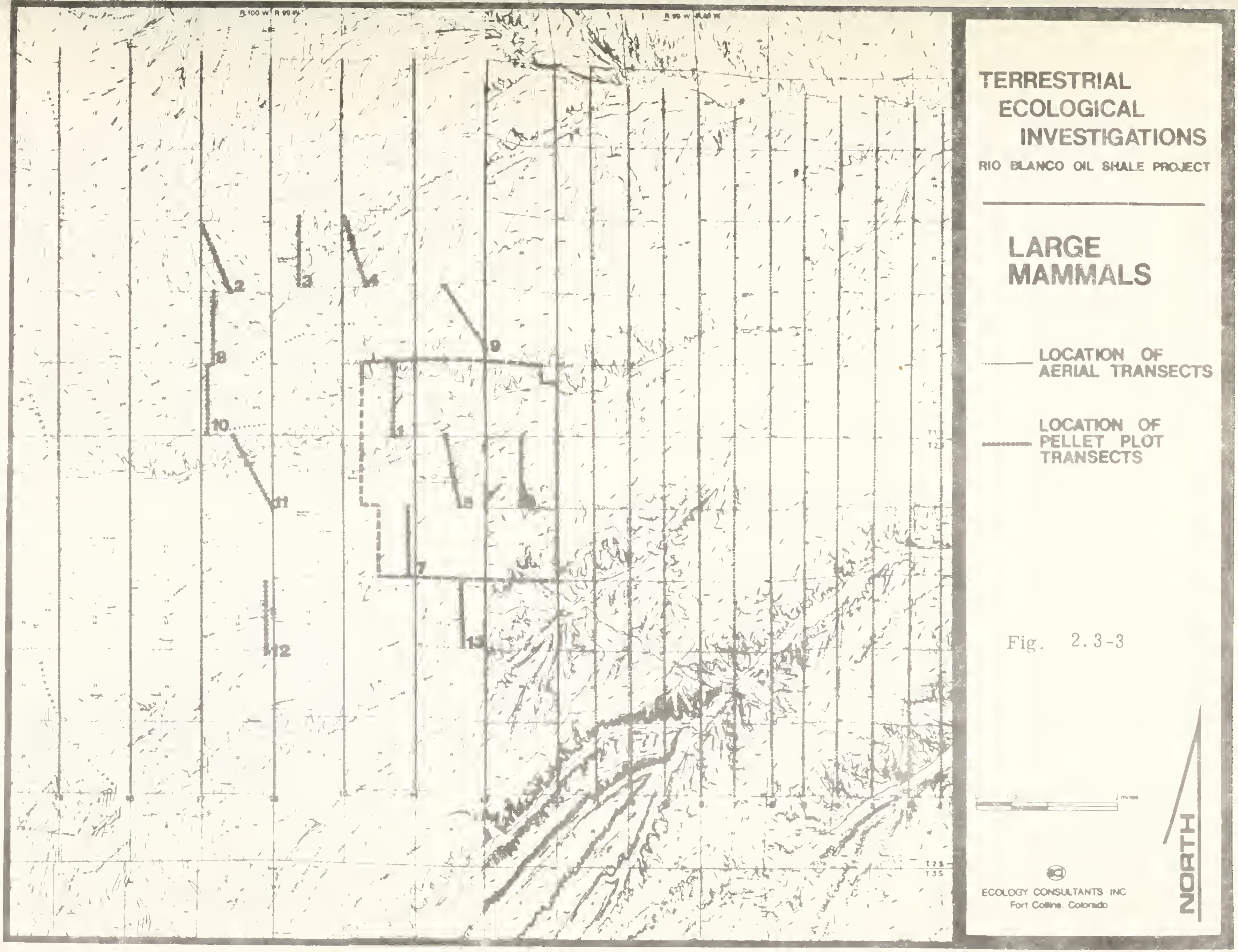
TERRESTRIAL
ECOLOGICAL
INVESTIGATIONS
RIO BLANCO OIL SHALE PROJECT
LARGE
MAMMALS
LOCATION OF
AERIAL TRANSECTS
LOCATION OF
PELLET PLOT
TRANSECTS
2 miles
NORTH
ECOLOGY CONSULTANTS INC
Fort Collins, Colorado
R 100 W R 99 W
R 99 W R 98 W
T 1 S
T 2 S
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Fig. 2.3-3

2.3.4.3 Results

Large mammal aerial surveys were conducted on June 26 and August 18, 1975. The number of mule deer, elk and feral horses observed during each survey is presented in Table 2.3-4. Deer or elk were not observed during the surveys. Most of the feral horses seen were observed in the southwest quarter of the study area during the aerial counts (Figure 2.3-4). More horses were observed during the June survey than during the August count. The species of large mammals encountered in the study area to date are included in Table 2.3-2.

2.3.5 Mammalian Predators

2.3.5.1 Objectives

No change has occurred since Progress Report 2-Summary. See section 2.3.5.1 in Progress Report 2-Summary for the objectives of the mammalian predator studies.

2.3.5.2 Methods

No change has occurred since Progress Report 2-Summary. See section 2.3.5.2 in Progress Report 2-Summary for methods used in mammalian predator studies.

2.3.5.3 Results

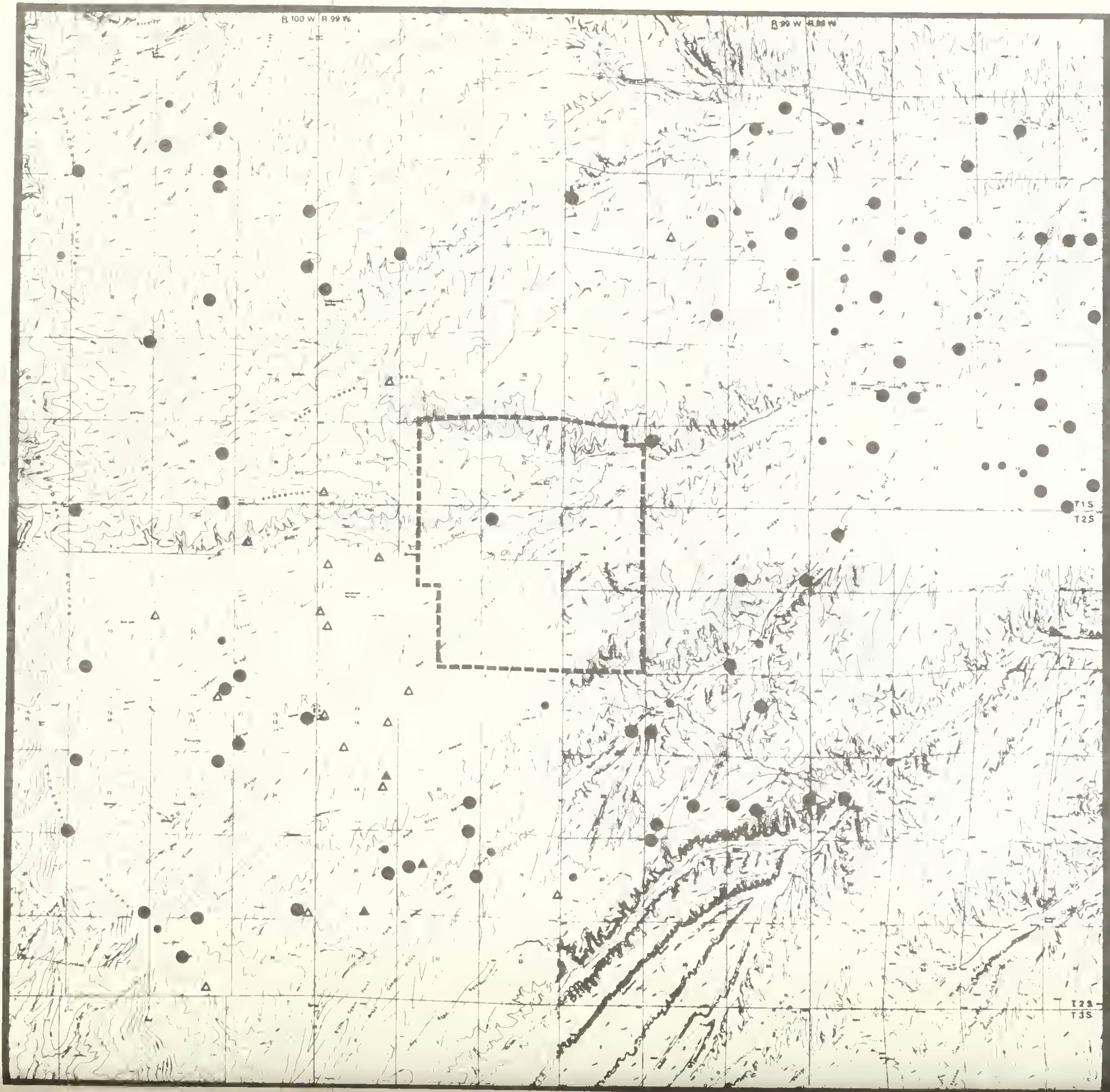
Records of tracks, scats and other definitive sign recorded by ECI personnel on and near Tract C-a to date as well as the results of the scent-station visitation census indicate that the coyote (Canis latrans) and the weasel (Mustela sp.) are the most abundant mammalian predators in the area. Both the long-tailed weasel (Mustela frenata) and the ermine (Mustela erminea) have been captured during live trapping.

Other mammalian predators that have been documented by tracks and direct observation on the site to date are the bobcat (Lynx rufus) and the badger (Taxidea taxus). Havahart traps were unsuccessful in recording the presence of small predators during June and July sampling. Further terrestrial investigations should yield additional species. The species of mammalian predators encountered in the study area to date are included in Table 2.3-2.

2.3.6 Winter Track Counts

Table 2.3-4. Number of mule deer, elk, and feral horses observed during aerial censuses on June 26 and August 18, 1975 for RBOSP

Date	Mule Deer	Elk	Feral Horses		
			Adult	Foal	Unidentified
June 26	0	0	69	24	0
August 18	0	0	55	8	0
Totals	0	0	124	32	0



TERRESTRIAL ECOLOGICAL INVESTIGATIONS

RIO BLANCO OIL SHALE PROJECT

LARGE MAMMALS

AERIAL CENSUS

JUNE-AUGUST, 1975

NUMBER AND APPROXIMATE LOCATIONS OF FERAL HORSES AND DOMESTIC LIVESTOCK

	1-10	11-20
FERAL HORSES	△	▲
DOMESTIC LIVESTOCK	●	•

Fig. 2.3-4

0 1/2 1 2 miles

NORTH

ECOLOGY CONSULTANTS INC.
Fort Collins, Colorado

2.3.6.1 Objectives

No change has occurred since Progress Report 2-Summary. See section 2.3.6 in Progress Report 2-Summary for the objectives of the winter track count studies.

2.3.6.2 Methods

No change has occurred since Progress Report 2-Summary. See section 2.3.6 in Progress Report 2-Summary for methods used in winter track count studies.

2.3.6.3 Results

Winter track count data were not gathered during the reporting quarter June through August, 1975.

2.3.7 Avifauna

2.3.7.1 Objectives

No change has occurred since Progress Report 2-Summary. See section 2.3.7.1 in Progress Report 2-Summary for objectives of avifauna studies.

2.3.7.2 Methods

Methods of censusing avifauna include transect counts, walk-through surveys, examination of active songbird and raptor nests, upland gamebird censuses, aerial and ground censuses of raptors, night counts of owls, and waterfowl surveys.

2.3.7.3 Results

The June sampling period occurred during the height of the breeding season for most avian species. The variety of vegetation types present in the study area provides suitable nesting sites for many species, as demonstrated by the relatively high avian diversity recorded during the summer season. Of the 96 species recorded during this sampling period, 42 species had not been previously recorded by ECI personnel on the study area. This brings the total to 127 species recorded within the area of investigation. The mallard, mountain bluebird, green-tailed towhee, chipping sparrow, Brewer's sparrow and vespar sparrow were the most frequently observed species during the summer sampling period. Table 2.3-5 includes a list of all avian species observed in the study area to date.

Table 2.3-5. Species of birds observed during field investigations to date in the vicinity of Tract C-b for RBOSP [1]

ORDER FAMILY Species	Common Name
CICONIIFORMES	
ARDEIDAE	
Ardea herodias	Great blue heron
CICONIIDAE	
Plegadis chihi	White-faced ibis
ANSERIFORMES	
ANATIDAE	
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anas crecca	Green-winged teal
Anas discors	Blue-winged teal
Anas cyanoptera	Cinnamon teal
Aythya americana	Redhead
FALCONIFORMES	
CATHARTIDAE	
Cathartes aura	Turkey vulture
ACCIPITRIDAE	
Accipiter gentilis	Goshawk
Accipiter striatus	Sharp-shinned hawk
Accipiter cooperii	Cooper's hawk
Buteo jamaicensis	Red-tailed hawk
Buteo swainsoni	Swainson's hawk
Buteo lagopus	Rough-legged hawk
Aquila chrysaetos	Golden eagle
Haliaeetus leucocephalus	Bald eagle
Circus cyaneus	Marsh hawk
FALCONIDAE	
Falco mexicanus	Prairie falcon
Falco peregrinus	Peregrine falcon
Falco sparverius	American kestrel

Table 2.3-5. (Continued)

ORDER FAMILY Species	Common Name
GALLIFORMES	
TETRAONIDAE	
Dendragapus obscurus	Blue grouse
Centrocercus urophasianus	Sage grouse
GRUIFORMES	
GRUIDAE	
Grus canadensis tabida	Greater sandhill crane
RALLIDAE	
Rallus limicola	Virginia rail
Porzana carolina	Sora
CHARADRIIFORMES	
CHARADRIIDAE	
Charadrius semipalmatus	Semipalmated plover
Charadrius vociferus	Killdeer
SCOLOPACIDAE	
Capella gallinago	Common snipe
Actitis macularia	Spotted sandpiper
Actitis macularia	Solitary sandpiper
Tringa flavipes	Lesser yellowlegs
Numenius americanus	Long-billed curlew
RECURVIROSTRIDAE	
Recurvirostra americana	American avocet
PHALAROPODIDAE	
Steganopus tricolor	Wilson's phalarope
COLUMBIFORMES	
COLUMBIDAE	
Zenaida macroura	Mourning dove
STRIGIFORMES	
STRIGIDAE	
Otus asio	Screech owl
Bubo virginianus	Great horned owl
Glaucidium gnoma	Pygmy owl
Asio flammeus	Short-eared owl

Table 2.3-5. (Continued)

ORDER FAMILY Species	Common Name
CAPRIMULGIFORMES	
CAPRIMULGIDAE	
Phalaenoptilus nuttallii	Poor-will
Chordeiles minor	Common night hawk
APODIFORMES	
APODIDAE	
Aeronautes saxatalis	White-throated swift
TROCHILIDAE	
Selasphorus platycercus	Broad-tailed hummingbird
PICIFORMES	
PICIDAE	
Colaptes auratus	Common flicker
Dendrocopos pubescens	Downy woodpecker
PASSERIFORMES	
TYRANNIDAE	
Sayornis saya	Say's phoebe
Empidonax hammondii	Hammond's flycatcher
Empidonax wrightii	Gray flycatcher
Contopus sordidulus	Western wood pewee
ALAUDIDAE	
Eremophila alpestris	Horned lark
HIRUNDINIDAE	
Tachycineta thalassina	Violet-green swallow
Iridoprocne bicolor	Tree swallow
Stelgidopteryx ruficollis	Rough-winged swallow
Hirundo rustica	Barn swallow
Petrochelidon pyrrhonota	Cliff swallow

Table 2.3-5. (Continued)

ORDER FAMILY Species	Common Name
PASSERIFORMES (Continued)	
CORVIDAE	
Cyanocitta stelleri	Steller's jay
Aphelocoma coerulescens	Scrub jay
Pica pica	Black-billed magpie
Corvus corax	Common raven
Corvus brachyrhynchos	Common crow
Gymnorhinus cyanocephalus	Pinyon jay
Nucifraga columbiana	Clark's nutcracker
PARIDAE	
Parus atricapillus	Black-capped chickadee
Parus gambeli	Mountain chickadee
Parus inornatus	Plain titmouse
Psaltriparus minimus	Bushtit
SITTIDAE	
Sitta carolinensis	White-breasted nuthatch
Sitta canadensis	Red-breasted nuthatch
Sitta pygmaea	Pygmy nuthatch
CERTHIIDAE	
Certhia familiaris	Brown creeper
TROGLODYTIDAE	
Troglodytes aedon	House wren
Salpinctes obsoletus	Rock wren
MIMIDAE	
Oreoscoptes montanus	Sage thrasher
TURDIDAE	
Turdus migratorius	American robin
Catharus guttata	Hermit thrush
Sialia currucoides	Mountain bluebird
Myadestes townsendii	Townsend's solitaire

Table 2.3- 5. (Continued)

ORDER FAMILY Species	Common Name
PASSERIFORMES (Continued)	
SYLVIIDAE	
Polioptila caerulea	Blue-gray gnatcatcher
Regulus calendula	Ruby-crowned kinglet
MOTACILLIDAE	
Anthus spinoletta	Water pipit
BOMBYCILLIDAE	
Bombycilla cedrorum	Cedar waxwing
LANIIDAE	
Lanius excubitor	Northern shrike
Lanius ludovicianus	Loggerhead shrike
STURNIDAE	
Sturnus vulgaris	Starling
VIREONIDAE	
Vireo vicinior	Gray vireo
Vireo solitarius	Solitary vireo
Vireo olivaceus	Red-eyed vireo
Vireo gilvus	Warbling vireo
PARULIDAE	
Vermivora peregrina	Tennessee warbler
Vermivora celata	Orange-crowned warbler
Vermivora virginiae	Virginia's warbler
Dendroica petechia	Yellow warbler
Dendroica coronata	Yellow-rumped warbler
Dendroica nigrescens	Black-throated gray warbler
Oporornis tolmiei	MacGillivray's warbler
PLOCEIDAE	
Passer domesticus	House sparrow

Table 2.3- 5. (Continued)

ORDER FAMILY Species	Common Name
PASSERIFORMES (Continued)	
ICTERIDAE	
Dolichonyx oryzivorus	Bobolink
Sturnella neglecta	Western meadowlark
Agelaius phoeniceus	Red-winged blackbird
Euphagus cyanocephalus	Brewer's blackbird
Molothrus ater	Brown-headed cowbird
THRAUPIDAE	
Piranga ludoviciana	Western tanager
FRINGILLIDAE	
Pheucticus melanocephalus	Black-headed grosbeak
Carpodacus cassinii	Cassin's finch
Carpodacus mexicanus	House finch
Leucosticte australis	Brown-capped rosy finch
Spinus pinus	Pine siskin
Loxia curvirostra	Red crossbill
Chlorura chlorura	Green-tailed towhee
Pipilo erythrophthalmus	Rufous-sided towhee
Calamospiza melanocorys	Lark bunting
Ammodramus savannarum	Grasshopper sparrow
Ammodramus bairdii	Baird's sparrow
Pooecetes gramineus	Vesper sparrow
Chondestes grammacus	Lark sparrow
Amphispiza belli	Sage sparrow
Junco hyemalis	Dark-eyed junco
Junco caniceps	Gray-headed junco
Spizella arborea	Tree sparrow
Spizella passerina	Chipping sparrow
Spizella breweri	Brewer's sparrow

Table 2.3-5. (Continued)

ORDER FAMILY Species	Common Name
PASSERIFORMES (Continued)	
FRINGILLIDAE (Continued)	
Zonotrichia leucophrys	White-crowned sparrow
Passerella iliaca	Fox sparrow
Melospiza melodia	Song sparrow
Calcarius mccownii	McCown's longspur
Calcarius ornatus	Chestnut-collared longspur
Plectrophenax nivalis	Snow bunting

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[1] The following authorities are used for bird nomenclature:

American Ornithologists' Union. 1957. Checklist of North American Birds, Fifth edition. Port City Press, Baltimore, Maryland. 691 pages.

American Ornithologists' Union. 1973. Thirty-second supplement to the American Ornithologists' Union checklist of North American Birds (Fifth edition, 1957). Auk 90:411-419.

The riparian community and adjacent habitats supported the greatest bird density and diversity during the June sampling period while the sagebrush and rabbitbrush communities supported the lowest number of different bird species and individuals.

In the Tract C-a vicinity, a few surface ponds and streams create isolated islands of habitat for many waterfowl species within the predominantly arid region that is northwestern Colorado. For this reason, representatives of such habitat types have an unusually high ecological value within this region. Fourteen waterfowl and shorebird species have been recorded within the vicinity of Tract C-a on and around the few small ponds and streams in the area.

A fairly large population of breeding raptors was present in the area of investigation during June, 1975. The most abundant species observed were the common raven, American kestrel and red-tailed hawk. The majority of the nesting raptors present in the area were found in the pinyon-juniper woodlands and on the associated sandstone cliffs.

Field data collected during summer 1975, indicate that most avian species encountered in the area of investigation were those expected to be present based on published information from northwestern Colorado and northeastern Utah (Bailey and Niedrach, 1965; Davis, 1969; Hayward, 1967; Twomey, 1942).

Several unexpected species such as the Virginia rail, sora, long-billed curlew, semi-palmated plover, red-eyed vireo, bobolink and Baird's sparrow were encountered during field sampling. All such species except Baird's sparrow have been recorded previously in northwestern Colorado but only as unusual occurrences.

2.3.8 Reptiles and Amphibians

2.3.8.1 Objectives

No change has occurred since Progress Report 2-Summary. See section 2.3.8 in Progress Report 2-Summary for the objectives of the reptile and amphibian section.

2.3.8.2 Methods

Line transect methods are employed to sample reptiles and amphibians in all major habitat types on and near Tract C-a. Ten transects, each approximately 1000 m (3280 ft) in length, are surveyed once during June and August 1975 and 1976 by two observers walking far enough apart to preclude duplicate observations. Five transects are permanently located, one in each of the five major vegetation types (pinyon-juniper on north and south facing slopes, sagebrush, greasewood-sagebrush, and mixed brush). Non-permanent transects are relocated during each sampling period such that all vegetation types are sampled at least once during the two-year period. Species, numbers, microhabitat type, sex and age class (when possible), various environmental parameters, and other data are recorded on a standard field data sheet.

Information regarding nocturnally active amphibian species is gathered opportunistically by ECI field personnel. Two nights during May and June, 1975 and 1976, are devoted to sampling potential amphibian breeding sites (ponds) on and near Tract C-a. Species, numbers, habitat description, sex and age class are recorded on a standard field data sheet.

The first individual of each species encountered in the area is killed by an injection of phenobarbital and prepared as a voucher specimen.

2.3.8.3 Results

Five reptile species were encountered on 20 herpetofauna line transect surveys conducted during June and August, 1975. The sagebrush lizard appears to be the most abundant reptile species in the study area; 50 of these lizards were observed or captured on six surveys at four different locations. The other reptile species encountered, but in fewer numbers, were the eastern fence lizard, tree lizard, short-horned lizard and western terrestrial garter snake. Greatest abundances of lizards were observed on transects within the pinyon-juniper vegetation type.

2.3.9 Terrestrial Invertebrates

2.3.9.1 Objectives

The objectives of the terrestrial invertebrate investigations are to collect and identify the abundant invertebrates associated with the major vegetation types, and to qualitatively and quantitatively describe the invertebrates whose host are made up of the dominant plant species within these habitats. These data serve as a basis for determination of the role of invertebrates in the ecosystem and a basis for future comparative studies on Tract C-a and the surrounding area.

2.3.9.2 Methods

Field sampling is scheduled at five sites during May, July, and September of 1975 and 1976. The sampling sites are selected to concentrate on the major vegetation types; sagebrush-rabbitbrush (with some greasewood) bottomland, south-facing pinyon-juniper, north-facing pinyon-juniper, upland sagebrush, and mixed brush.

A variety of field sampling techniques is employed to capture invertebrates in different microhabitats at each sampling station, including pitfalls, malaise traps, sweeping, beating, litter, and trap-D-Vac samples.

2.3.9.3 Results

Seven different methods (pitfalls, litter D-Vac, trap D-Vac, herbaceous sweeps, beating, and ground and aerial sweeps) were employed to sample invertebrates both quantitatively and qualitatively at five sites, each in a different vegetation type during June 1975. The invertebrate groups collected and identified to date from RBOSP are listed in Table 2.3-6.

Ground dwelling invertebrates, as sampled by pitfalls and litter D-Vac techniques were most abundant at site 4 (sagebrush). The predominant ground dwelling groups in samples from all sites included Collembola (the most abundant), mites (Acari), spiders (Araneida), and ants (Hymenoptera - Formicidae).

The dominant species within the shrub and tree strata and the herbaceous stratum were sampled by ground level sweeps (herbaceous), trap D-Vac samples, beating samples and aerial sweeps. The primary emphasis of these samples was to identify species of invertebrates which potentially have close relationships with the plant species they inhabit, and to give rough quantitative estimates of their density per cubic meter of the dominant shrub species.

A comparison of trap D-Vac and herbaceous sweep results indicates that sagebrush (Artemisia tridentata) has the largest invertebrate fauna per unit area of plant, followed closely by rabbitbrush. In herbaceous sweep samples, the largest number of invertebrates was taken at the greasewood-sagebrush site (Site 1). Overall, it appeared that the two sagebrush sites had the largest total invertebrate populations in the shrub and ground vegetation strata. Predominant invertebrate groups captured by trap D-Vac included Curculionidae, Formicidea, and Acari at all sites, as well as Thysanoptera and Anthicidea on individual plant species. For herbaceous sweep samples, the predominant invertebrate families captured were Cicadellidae and Formicidae for all sites.

Table 2.3-6. Invertebrate groups collected and identified to date for RBOSP

ORDER/Family

- THYSANURA
  - Machilidae
- COLLEMBOLA
  - Isotomidae
  - Entomobryidae
  - Sminthuridae
- ORTHOPTERA
  - Acrididae
  - Gryllacrididae
- PSOCOPTERA
  - Trogiidae
- THYSANOPTERA
- HEMIPTERA
  - Miridae
  - Reduviidae
  - Tingidae
  - Aradididae
  - Lygaeidae
  - Pentatomidae
- HOMOPTERA
  - Cicadellidae
  - Delphacidae
  - Psyllidae
  - Aphididae
  - Coccoidea (super family)
- COLEOPTERA
  - Carabidae
  - Histeridae
  - Staphylinidae
  - Scydmaenidae
  - Cantharidae
  - Lampyridae
  - Dermestidae
  - Ostomidae
  - Cleridae
  - Elateridae
  - Erotylidae
  - Lathridiidae

ORDER/Family

- COLEOPTERA (Cont.)
  - Coccinellidae
  - Anthicidae
  - Meloidae
  - Tenebrionidae
  - Melandryidae
  - Ptinidae
  - Anobiidae
  - Scarabaeidae
  - Byrrhidae
  - Chrysomelidae
  - Curculionidae
  - Scolytidae
- NEUROPTERA
  - Hemerobiidae
  - Myrmeleontidae
- LEPIDOPTERA
  - Hesperidae
  - Arctiidae
  - Noctuidae
  - Geometridae
  - Pyralidoidea (super famil
  - Pterophoridae
  - Tortricoidea (super famil
- DIPTERA
  - Tipulidae
  - Psychodidae
  - Chironomidae
  - Simulidae
  - Bibionidae
  - Mycetophilidae
  - Sciaridae
  - Cecidomyiidae
  - Therevidae
  - Asilidae
  - Empididae
  - Dolichopodidae
  - Phoridae
  - Pipunculidae
  - Syrphidae
  - Otitidae
  - Tephritidae

Table 2.3- 6. (Continued)

ORDER/Family

DIPTERA (Cont.)
- Sepsidae
- Sciomyzidae
- Chamaemyiidae
- Lonchaeidae
- Chloropidae
- Heleomyzidae
- Trixoscelididae
- Agromyzidae
- Anthomyiidae
- Muscidae
- Calliphoridae
- Tachinidae

HYMENOPTERA
- Xyelidae
- Tenthredinidae
- Braconidae
- Ichneumonidae
- Mymaridae
- Eulophidae
- Encyrtidae
- Eupelmidae
- Pteromalidae
- Chalcididae
- Figitidae
- Cynipidae
- Proctotrupidae
- Diapriidae
- Scelionidae
- Platygasteridae
- Bethylidae
- Dryinidae
- Formicidae
- Vespidae
- Sphecidae
- Colletidae
- Andrenidae
- Halictidae
- Megachilidae
- Apidae

SCORPIONIDA

CHELONETHIDA

SOLPUGIDA

ORDER/Family

ARANEIDA
- Dictynidae
- Hahniidae
- Lycosidae
- Oxyopidae
- Gnaphosidae
- Thomisidae
- Salticidae

PHALANGIDA

ACARI

GEOPHILOMORPHA

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[1] Common names, correct spelling, and taxonomic order from: Borror, D.J. and DeLong, D.M. 1971. An Introduction to the study of Insects. Holt, Rinehart, and Winston. New York. 812 pp.

Beating and sweeping samples from tall shrubs and trees at Sites 1, 2, and 3 (greasewood-sagebrush, pinyon-juniper/south slope and pinyon-juniper/north slope) showed the overall invertebrate abundance to be greatest at Site 2, followed by Site 1. Comparisons between north and south slope pinyon-juniper sites (Sites 3 and 2) show a distinct difference in total invertebrate numbers, with both pinyon and juniper trees yielding larger numbers of invertebrates at Site 2 (south slope). Within these sites, it appears from samples that the population of invertebrates inhabiting juniper trees is much larger than that from pinyon trees.

Predominant groups from sagebrush included Miridae, Cicadellidae, Aphididae, Acari, and Thysanoptera. In pinyon samples, one species of ant (Tapinoma sessile) was the most abundant species taken, and in juniper samples one species of Miridae was found most abundantly in nearly every sample.

Adjusted totals for Malaise samples indicate that invertebrates were most abundant in the pinyon-juniper/north slope site (Site 3). Predominant groups sampled by Malaise traps at all sites were in the order Diptera, with Chiromidae the most abundant family collected. Other abundant families of Diptera were Mycctophilidae, Sciaridae, Cecidomyidae, Syrphidae, Chamaemyiidae, Trixoscelididae, Anthomyiidae, and Callophoridae. In Hymenoptera, predominant families captured by Malaise traps were Ichneumonidae, Broconidae, and Pteromalidae.

Overall, it appears that Site 4 (sagebrush) supported the most abundant invertebrate fauna of all sites sampled.

2.3.10 Domestic Livestock

2.3.10.1 Objectives

Numbers of livestock on the study area are being determined and areas of concentration are being estimated on a seasonal basis to help define the extent and type of grazing pressure exerted by domestic herbivories.

2.3.10.2 Methods

Aerial censuses are being used to determine the locations of domestic livestock within the area of investigation. The domestic livestock censuses are conducted bimonthly in conjunction with the large mammal aerial censuses. Since the censuses are conducted concurrently, the data gathering procedures are identical to those described for the large mammal aerial surveys. When livestock are sighted during the aerial censuses, location and number of individuals are recorded into cassette tape recorders.

2.3.10.3 Results

Aerial surveys of domestic livestock were conducted in conjunction with the large mammal aerial surveys on June 26 and August 18, 1975. During the June census, 752 cattle were observed. The majority of the cattle was located in 84 Mesa and in areas south and east of Tract C-a (Figure 2.3-3). In contrast to the livestock distribution noted during the June survey, most of the cattle observed during August were located west of Tract C-a in mountain brush areas. The screening effects of the heavy brush may have resulted in many cattle being overlooked during the surveys. Only 101 domestic livestock were observed during the August count.

2.3.11 Remote Sensing

2.3.11.1 Objectives

Several ongoing investigations to determine the applicability of remote sensing techniques for acquisition of terrestrial baseline data are included in the terrestrial baseline program. These include investigations of the distribution, areal extent and crown density status of the vegetation community types; erosion condition; distribution of wildlife habitat for large and small mammals; distribution of western harvester ant colonies; and locations of suspected habitat of major avifauna including raptor species.

2.3.11.2 Methods

One flight to obtain color infrared (CIR) imagery at a scale of 1:6000 is to be conducted in September of 1975. Coverage at the 1:6000 scale will provide imagery of the entire 400 km^2 (170 mi^2) study area.

The mapping flight is designed to provide imagery of sufficiently high quality to obtain the maximum amount of information available. A qualified subcontractor will perform the flight.

Analysis of CIR transparencies is conducted using a variable intensity light table with a mounted zoom stereoscope. Interpretations are made directly on the imagery using water soluble ink. Interpreted information is then transferred to 1:24000 mylar reproductions of USGS 7-1/2 minute topographic quadrangles.

2.3.11.3 Results

Remote sensing data were not gathered during the reporting quarter June through August, 1975.

2.3.12 Threatened and Endangered Species

2.3.12.1 Objectives

Federal and State wildlife agencies have compiled lists of species which may be considered "threatened", "rare" or "endangered". If any of these species are present in the study area they will be identified and their location and reliance on local habitats determined.

2.3.12.2 Methods

Throughout earlier sections of this and previous Progress Reports, specific quantitative and qualitative sampling techniques have been described which are to be performed within all major vegetation associations in the tract vicinity to inventory and enumerate the species of plants and animals present. Cumulatively these techniques should ascertain the presence of threatened, rare or endangered species. Once discovered, special efforts may be directed as determining the distribution and habitat utilization of the species on and near Tract C-a. The greater sandhill crane, endangered as a nesting species in the state of Colorado, has been observed on 84 Mesa north of Tract C-a and has therefore been subjected to this close scrutiny.

2.3.12.3 Results

During the reporting quarter June-August 1975, three threatened, endangered or status-undetermined animal species and one endangered plant species were observed. Three individual observations each were recorded for the prairie falcon and the peregrine falcon, although no nests for either species were encountered. A special study was conducted to investigate the status of greater sandhill cranes in the study area. An endangered plant (*Astragalus lutosus*, Smithsonian Institution, 1975) was observed near Cottonwood Spring during the summer quarter.

The extent to which greater sandhill cranes (*Grus canadensis tabida*) utilize 84 Mesa, and other locations within a radius of miles of 84 Mesa was investigated between April and July 1975. Ground and aerial surveys as well as personal interviews with residents of the Piceance Basin revealed no evidence that these areas are currently used by this species for nesting. However, based on observations made during April 1975, 84 Mesa may serve as a staging and foraging area for greater sandhill cranes during their spring migration; suitable habitats adjacent to the mesa may serve as foraging sites. It is unknown if birds staging in this area of the Piceance Basin eventually nest in Colorado or if they continue migration to breeding areas farther north.

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2.4 Aquatic Studies

The Aquatic Baseline Data Accumulation Program is intended to perform those environmental studies described in the Federal Register, Volume 39, Number 230, Part 3, Oil Shale Lease Environmental Stipulations and in the Tract C-a Exploratory plan of May 1974. Specific lease requirements addressed were "The Lessee shall make studies of the flora and fauna ...and also of the aquatic habitat as far downstream as the Mining Supervisor shall require." "The Lessee shall compile an inventory of natural surface features, such as springs and seeps."

No detailed studies of the aquatic ecosystems of Tract C-a have been made prior to the present baseline study. However, studies of similar habitats indicate that the composition and abundance of the aquatic flora and fauna are primarily determined by the permanency of flow.

The overall objective for the Aquatic Baseline Data Accumulation Program is to characterize the existing aquatic communities on and in the vicinity of Tract C-a. These studies will inventory aquatic habitats which may be affected by oil shale development. The ongoing programs are summarized in Table 2.4-1.

In order to fulfill these objectives, 35 sampling stations have been selected to represent the aquatic habitats present. Emphasis has been placed on Yellow Creek and the White River which are permanently flowing streams. The locations of aquatic sampling stations are depicted in Figure 2.4-1. Sampling periods discussed herein are April 1975, May - June and July - August 1975. The condition (dry or flowing) of each station during this period and dates on which aquatic samples were taken during May - June and July - August are shown in Table 2.4-2. (Flow condition and dates of sampling for April were presented in Progress Report 3 and will not b repeated here.) Physical, chemical, and biological measurements are taken concurrently at each sampling site.

2.4.1 Physical and Chemical Characteristics

2.4.1.1 Objectives

No change in objectives has occurred since Progress Report 3. See section 2.4.1.1 of Progress Report 3 for specific objective

Table 2.4-1. Summary of RBOSP Aquatic Sampling Programs
May - June and July - August 1975

Group Sampled	Objective	Methodology	No. of Sample Sites May-June	 July-August
Physical measurements	To measure existing physical parameters	Flow, O_2, pH, Cond., and temp. meters	28	30
Water Chemistry	Analysis of certain chemical characteristics of particular biological significance	Pump-type or bottle-type	28	30
Phytoplankton	Population studies and species inventory	Pump-type or bottle-type	28	30
Zooplankton	Population studies and species inventory	Wisconsin nets w/flow meter or pump	28	30
Periphyton	To estimate abundance, determine biomass and productivity	Scraped off rock	28	30
Benthos	Population studies and species inventory	Ekman, modified Surber, D-frame	28	30
Macrophytes	Species inventory	Random transect	28	30
Fish	Population studies, species inventory, condition, food habits	Electrofishing/ seining	15	15
Sediment chemistry	To measure existing chemical characteristics		28	30
Rare and endangered species			Opportunistic	
Springs & seeps			Opportunistic	
Water quality	To measure existing water quality in the White River near Yellow Creek		2	-

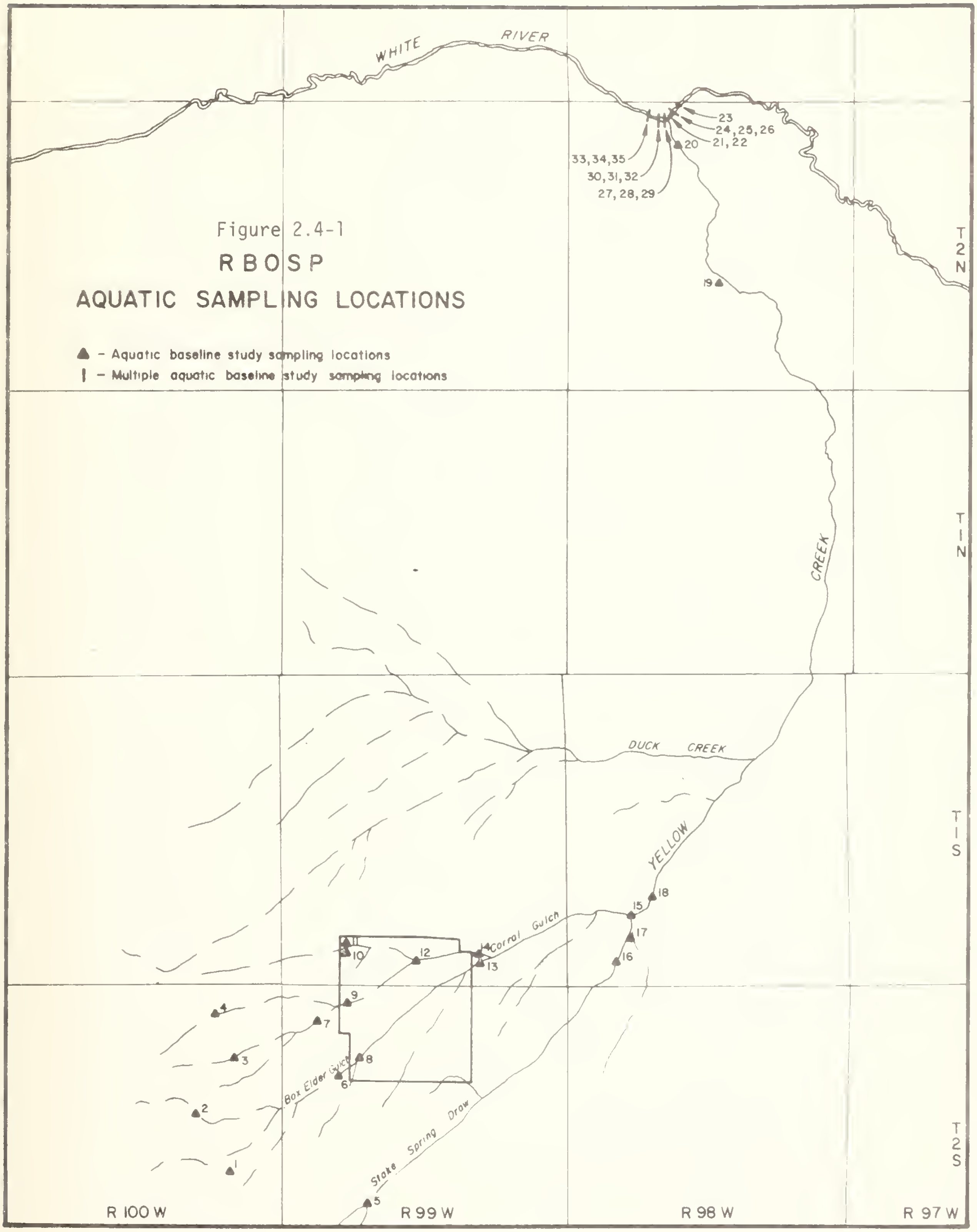

Figure 2.4-1

RBOSP

AQUATIC SAMPLING LOCATIONS

Table 2.4-2 Dates of sampling for RBOSP Aquatic Baseline Studies. May - June 1975 and July - August 1975

Station	Date Sampled	Flow Condition
1	6-18-75	Flowing
2	6- 4-75	Flowing
3	6- 5-75	Flowing
4	6- 5-75	Flowing
5	6- 3-75	Flowing
6	5-29-75	Flowing
7	6- 2-75	Flowing
8	5-28-75	Flowing
9	6- 2-75	Flowing
10	5-27-75	Dry
11	5-27-75	Dry
12	5-27-75	Dry
13	6- 2-75	Flowing
14	6- 3-75	Flowing
15	5-27-75	Dry
16	5-27-75	Dry
17	5-27-75	Dry
18	5-27-75	Dry
19	6- 3-75	Flowing
20	7- 1-75	Flowing
21	7- 1-75	Flowing
22	6-27-75	Flowing
23	6-27-75	Flowing
24	6-24-75	Flowing
25	6-24-75	Flowing
26	6-24-75	Flowing
27	6-26-75	Flowing
28	6-26-75	Flowing
29	6-26-75	Flowing
30	6-23-75	Flowing
31	6-23-75	Flowing
32	6-23-75	Flowing
33	6-25-75	Flowing
34	6-25-75	Flowing
35	6-25-75	Flowing

Table 2.4-2 (Continued)

Station	Date Sampled	Flow Condition
1	7-18-75	Flowing
2	7-18-75	Flowing
3	7-17-75	Flowing
4	7-17-75	Flowing
5	7-21-75	Flowing
6	7-15-75	Dry
7	7-15-75	Flowing
8	7-15-75	Flowing
9	7-15-75	Flowing
10	7-15-75	Dry
11	7-15-75	Dry
12	7-15-75	Dry
13	7-15-75	Flowing
14	7-21-75	Flowing
15	7-21-75	Flowing
16	7-15-75	Dry
17	7-21-75	Flowing
18	7-16-75	Flowing
19	8- 6-75	Flowing
20	8- 5-75	Flowing
21	8- 5-75	Flowing
22	8- 6-75	Flowing
23	8- 1-75	Flowing
24	7-28-75	Flowing
25	7-28-75	Flowing
26	7-28-75	Flowing
27	7-31-75	Flowing
28	8- 1-75	Flowing
29	7-31-75	Flowing
30	7-29-75	Flowing
31	7-29-75	Flowing
32	7-29-75	Flowing
33	7-30-75	Flowing
34	7-30-75	Flowing
35	7-30-75	Flowing

2.4.1.2 Methods

No change in methods has occurred since Progress Report 3. See section 2.4.1.2 of Progress Reports 2 and 3 for specific methods used in measuring the physical and chemical characteristics of the waters under study. See Table 2.4-3 for specific analytical methods.

2.4.1.3 Results

During the April 1975 sampling period, a total of eight sampling sites were dry. The dry sites included Stations 6, 10 - 12 and 15 - 18. During the May - June sampling period, the dry sites included Stations 10 - 12 and 15 - 18. During the July - August period, Stations 6, 10 - 12 and 16 were found to be dry. A summary of selected parameters for the White River and Yellow Creek stations is presented below.

	White River	Yellow Creek
Specific conductance (umhos)	250 - 450	1900 - 3600
pH	7.8 - 8.2	8.0 - 8.6
Alkalinity, total ($CaCO_3$ mg/l)	109 - 164	759 - 1449
Chloride (mg/l)	8 - 17	27 - 149
Sulfate (mg/l)	14 - 24	170 - 293
Dissolved solids (mg/l)	192 - 269	2100 - 2600
Turbidity (JTU)	29 - 77	3 - 7
Dissolved oxygen (mg/l)	8.1 - 9.1	8.2 - 12.9
Temperature (°C)	12 - 13	15 - 25

The physical and chemical data collected from stations on the White River (Stations 23 - 35) and from those on Yellow Creek (Stations 19 - 22) during the May - June period are generally within the same ranges of concentration reported by the USGS (1971, 1972, 1973) and by Everhart and May (1973) (refer to section 2.4.0 of Progress Report 2 for their findings). The exceptions for the White River were specific conductance, sulfate, and dissolved solids which, in some cases, were found in lower levels than were preveiously observed. In Yellow Creek, sulfate was observed in somewhat lower concentration than previously observed. The lower concentrations of certain constituents observed in the White River and Yellow Creek can probably be attributed to dilution from the high flows found in both streams during this sampling period. Turbidities observed in the White River and Yellow Creek during May - June period were considerably lower than those observed during April.

Table 2.4-3 Water and sediment chemistry, Analytical Laboratory Methodology. RBOSP Aquatic Baseline Studies.

Parameter	Measurement Methodology[1]	Detection Limit (ppm)[2]	Sample Preservation
	WATER CHEMISTRY		
Alkalinity, total	Colorimetric	2	None required
Ammonia nitrogen	Electrode	0.10	$HgCl_2$
Calcium, dissolved	Atomic absorption	0.02	None required
Chloride, dissolved	Potentiometric	0.4	None required
Hardness, total	EDTA Titration	2	None required
Magnesium, dissolved	Atomic absorption	0.005	HCl
Kjeldahl nitrogen	Kjeldahl digestion	0.10	$HgCl_2$
Nitrate, dissolved	Brucine	0.02	$HgCl_2$
Nitrite, dissolved	Diazotization	0.01	$HgCl_2$
Phosphate, ortho (dissolved)	Ammonium molybdate - potassium antimonyl tartrate	0.005	$HgCl_2$
Phosphate, total	Same as orthophosphate	0.01	$HgCl_2$
Potassium, dissolved	Atomic absorption	0.01	HCl
Silica, dissolved	Molybdosilicate	0.005	HCl
Sodium, dissolved	Atomic absorption	0.005	HCl
Sulfate, dissolved	Gravimetric	0.30	Refrigeration
Carbon, dissolved organic	Beckman TOC Analyzer	2	HCl
Carbon, total organic	Beckman TOC Analyzer	2	HCl
Solids, suspended	Filtration	1	None required
Solids, total dissolved	Filtration and evaporation	1	None required

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[1] Methods are those specified in the Federal Register, Vol. 38, No. 199, Oct. 16, 1973, except for use of specific ion electrode.

[2] For water samples, this detection limit is the minimum concentration which will be reported on natural and treated water samples (99.99% H O) with the indicated method and using a sample of defined size.

Table 2.4-3 (Continued)

Parameter	Measurement Methodology	Detection Limit (ppm)	Sample Preservation
	SEDIMENT CHEMISTRY[3]		
Arsenic	Extraction and Atomic absorption	1	Refrigeration
Aluminum	Extraction and Atomic absorption	10	Refrigeration
Herbicide	Gas Chromatography	100ppb	Refrigeration
Lead	Extraction and Atomic absorption	0.5	Refrigeration
Mercury	Extraction and Atomic absorption	0.02	Refrigeration
Nitrogen, total Kjeldahl	Kjeldahl digestion - Electrode	10	Refrigeration
Phosphate, total	Persulfate digestion	0.25	Refrigeration
Solids, total volatile	Filtration, evaporation volatilization	10	Refrigeration
Zinc	Extraction and Atomic absorption	0.5	Refrigeration

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[3] Detection limits vary with sample size.

2.4.2 Phytoplankton

2.4.2.1 Objectives

No change in objectives has occurred since Progress Report 2. See section 2.4.2.1 of Progress Report 2 for specific objectives.

2.4.2.2 Methods

No change in methods has occurred since Progress Report 2. See section 2.4.2.2 of Progress Report 2 for specific methods used in phytoplankton studies.

2.4.2.3 Results

Algal taxa observed in the April 1975 phytoplankton collections totaled 129.

During April, diatoms were generally the most abundant algal group at the headwater stations, although certain species belonging to the Chlorophyta and Cyanophyta were also quite abundant. The most abundant taxa were the diatoms *Achnanthes minutissima*, *Navicula pelliculosa* and *Gomphonema intricatum*, the chlorophyte *Ulothrix subtilissima* and the chrysophyte *Chrysidiastrum ocellatum*. At the tract stations, the most abundant taxa included an unidentified chlorophyte, the diatom *Achnanthes minutissima* and the chrysophyte *Chrysidiastrum ocellatum*. At Station 14 (a pond area), phytoplankton abundance was particularly high; the most abundant taxa at that location included the diatoms *Navicula arvensis*, N. *pelliculosa* and *Nitzschia frustulum* and the chrysophyte *Microsiphona potamos*. In Yellow Creek, diatoms were the most abundant phytoplankton group. The most abundant taxa in Yellow Creek included the diatoms Cyclotella meneghiniana, *Navicula pelliculosa*, *Nitzschia frustulum*, *Surrirella ovata*, which was particularly abundant at Stations 20 and 22; and the cryptophyte *Rhodomonas minuta* which was abundant at Station 19 on Yellow Creek. In the White River, the most abundant taxa was diatoms. The most abundant taxa included *Thalassiosira fluviatilis*, *Navicula cryptocephala*, N. *viridula* and an unidentified *chlorophyte*. *Cylindrothece gracilis* was especially abundant at Station 23.

Algal taxa observed in the phytoplankton collections made during the May - June 1975 sampling period totaled 121.

At the headwater stations, the most abundant algal taxon in the phytoplankton during May - June was the diatom *Achnanthes minutissima*. Phytoplankton abundance was generally low at all headwater stations, particularly at Station 2. At the tract stations, the most abundant taxa in the phytoplankton included the diatoms *Achnanthes minutissima*, *Nitzschia denticula* and *N. frustulum*, the blue-green alga *Chroococcus dispersus*, and an unidentified chlorophyte. Phytoplankton abundance was particularly low at Station 13. In Yellow Creek, the diatom *Cyclotella meneghiniana* was very abundant at Station 20 - 22. Other abundant taxa in Yellow Creek included the diatom *Achnanthes minutissima* and an unidentified flagellate; phytoplankton abundance was lower at Station 19 than at the other Yellow Creek stations. In the White River, the most abundant phytoplankton taxa included an unidentified cyanophyte, an unidentified chlorophyte and the diatom *Stephanodiscus tenuis*. Phytoplankton abundance in the White River was generally low during the May - June sampling period.

2.4.3 Zooplankton

2.4.3.1 Objectives

No change in objectives has occurred since Progress Report 2. See section 2.4.3.1 of Progress Report 2 for specific objectives.

2.4.3.2 Methods

In accordance with the revised aquatic scope of work of April 2, 1975, zooplankton samples are taken with a small submersible pump at all stations. Other methods remain unchanged from Progress Report 2. See section 2.4.3.2 of Progress Report 2 for specific methods.

2.4.3.3 Results

A total of 58 zooplankton taxa was observed in the April 1975 collections (both replicates). Data from the second replicate were very similar to the data previously reported for April (see Progress Report 3). At the headwater stations above Tract C-a, the most abundant taxa were *Centropyxis* species, sessile ciliates, bdelloid rotifers, unidentifiable contracted rotifers and crustacean nauplii. Abundant taxa at the tract stations was the same as for the headwater stations with the addition of *Notholca squamula*. At the Yellow Creek stations, the most abundant taxa were *Centropyxis* species, *Difflugia acuminata*, *Notholca acuminata*, bdelloid rotifers and contracted rotifers. White River stations were similar except that *D. acuminata* and *N. acuminata* were replaced in importance by sessile ciliates and *N. squamula*.

Zooplankton taxa encountered in May - June 1975 collections totaled 71. At the headwater stations, *Centropyxis* species, bdelloid rotifers and crustacean nauplii were the most abundant forms. These taxa were also very important quantitatively at the tract stations. A high diversity of rotifers was observed at Stations 5 and 14. This is of interest as Station 5 is immediately below a marshy pond area and Station 14 is located within a pond. In Yellow Creek, species abundance varied among stations, but *Notholca* species (*N. acuminata* and *N. squamula*) were generally most abundant. As at the stations located near the tract, the most abundant taxa at White River stations included *Centropyxis* species, bdelloid rotifers and crustacean nauplii. Also numerous were species of *Notholca*.

In the analysis of one replicate of the zooplankton collections of July - August 1975, a total of 58 taxa was observed. Analysis of the one replicate indicates that at the headwater stations above Tract C-a the most abundant taxa were *Centropyxis* species, contracted bdelloid rotifers and ostracods. At the tract stations, the most abundant taxa included *Centropyxis* species, *Vorticella* sp., *Euchlanis dilatata*, Crustacean nauplii and contracted notommatid rotifers. At the Yellow Creek stations, the most abundant taxa were *Centropyxis* species, notommatid rotifers, and *Eucyclops agilis*. *Centropyxis* species, notommatid rotifers and *Euchlanis dilatata* were the most abundant taxa at White River stations.

2.4.4 Periphyton

2.4.4.1 Objectives

No change in objectives has occurred since Progress Report 2. See section 2.4.4.1 of Progress Report 2 for specific objectives.

2.4.4.2 Methods

No change in methods has occurred since Progress Report 2. See section 2.4.4.2 of Progress 2 for specific methods.

2.4.4.3 Results

A total of 71 alga taxa was observed in the April 1975 periphyton collections. At the headwater stations, the most abundant taxa included the diatoms *Achnanthes minutissima*, *Synedra amphicephala* and *Gomphonema intricatum*. Periphyton abundance was low at Station 1 and high at Station 5. At the tract stations, the most abundant taxa included the blue-greens *Plectonema* spp. and the diatoms *Achnanthes minutissima* and *Navicula cryptocephala*. Periphyton abundance was particularly high at tract Station 14 (a pond area). In Yellow Creek, the most abundant algal taxa in the periphyton included the diatoms *Achnanthes minutissima*, *Navicula pelliculosa* and *Surirella ovata*. In the White River, the most abundant taxa were the diatoms *Navicula cryptocephala*, *N. tripunctata*, *N. viridula*, *Epithemia sorex* and *Nitzschia dissipata*.

The 89 algal taxa found in the periphyton collected during the May - June 1975 sampling period are listed in Table 2.4-4. At the headwater stations, the most abundant taxon was the diatom *Achnanthes minutissima* except at Station 1, where an unidentified chrysophyte was the most abundant alga. At the tract stations, there was little periphyton at any stations except Station 14 (a pond area) where several taxa were abundant. These abundant algae included the diatoms *Achnanthes minutissima*, *Cymbella affinis* and *Nitzschia denticula*. In Yellow Creek, the diatom *Achnanthes minutissima* was the most abundant taxon. In the White River, the diatoms *Amphora ovalis* var. *pediculus*, *Navicula cryptocephala* and *Nitzschia frustulum*, and the blue-green taxon *Calothrix* spp. Periphyton abundance varied considerably among sampling locations in the White River during the June sampling.

2.4.5 Benthos

2.4.5.1 Objectives

No change in objectives has occurred since Progress Report 2. See section 2.4.5.1 of Progress Report 2 for specific objectives.

2.4.5.2 Methods

The methods reported in section 2.4.5.2 of Progress Reports 2 and 3 remain unchanged, with the exception that the D-frame net was utilized during the May - June 1975 sampling of the White River. See section 2.4.5.2 of Progress Reports 2 and 3 for specific methods used in benthos sampling and analysis.

2.4.5.3 Results

One hundred and eighteen benthic taxa were observed in the samples taken during April 1975, and 92 taxa were collected during the May - June sampling. At the headwater stations

Table 2.4-4 List of algal taxa observed in the periphyton during RBOSP Aquatic Baseline Studies. May - June 1975

CYANOPHYTA
- *Anabaena* spp.
- *Calothrix* spp.
- *Lyngbya* spp.
- *Merismopedia glauca*
- *Plectonema* spp.
- *Schizothrix* spp.

CHLOROPHYTA
- *Closterium leibleinii*
- *Cladophora* spp.
- *Oedogonium* spp.
- *Ulothrix* spp.
- *Zygnema* spp.

CHRYSOPHYTA
- *Achnanthes hauckiana*
- *Achnanthes minutissima*
- *Amphiprora alata*
- *Amphora ovalis*
- *Amphora ovalis* var. *pediculus*
- *Amphora* spp.
- *Anomoeoneis* spp.
- *Asterionella formosa*
- *Caloneis amphisbaena*
- *Caloneis bacillum*
- *Cocconeis pediculus*
- *Cocconeis placentula*
- *Cyclotella meneghiniana*
- *Cylindrotheca gracilis*
- *Cymbella affinis*
- *Cymbella cistula*
- *Cymbella microcephala*
- *Cymbella obtususcula*
- *Cymbella prostrata*
- *Cymbella sinuata*
- *Cymbella ventricosa*
- *Diatoma hiemale*
- *Didymosphaenia geminata*
- *Epithemia sorex*
- *Epithemia zebra*
- *Fragilaria construens*
- *Fragilaria leptostauron*
- *Fragilaria pinnata*
- *Fragilaria vaucheriae*
- *Gomphonema intricatum*
- *Gomphonema olivaceum*

Table 2.4-4 (Continued)

Gomphonema parvulum
Gyrosigma acuminatum
Hantzschia amphioxys
Meridion circulare
Navicula arvensis
Navicula capitata
Navicula cryptocephala
Navicula cuspidata
Navicula fragilarioides
Navicula lanceolata
Navicula gregaria
Navicula mutica
Navicula pelliculosa
Navicula peregrina
Navicula radiosa
Navicula salinarum var. *intermedia*
Navicula seminulum
Navicula subminiscula
Navicula tantula
Navicula tripunctata
Navicula vaucheriae
Navicula viridula
Navicula spp.
Nitzschia acicularis
Nitzschia amphibia
Nitzschia apiculata
Nitzschia baccata
Nitzschia chasei
Nitzschia denticula
Nitzschia frustulum
Nitzschia hungarica
Nitzschia linearis
Nitzschia microcephala
Nitzschia palea
Nitzschia vermicularis
Pinnularia brebissonii
Pleurosigma delicatulum
Rhoicosphenia curvata
Rhopalodia gibba
Rhopalodia gibberula
Stephanodiscus tenuis
Surirella angustata
Surirella ovalis
Surirella ovata
Synedra amphicephala
Synedra pulchella
Synedra ulna

during both sampling periods, the most abundant taxa included Chironomidae, Amphipoda, Nematoda, Oligochaeta, Baetidae, Ceratopogonidae, Tipulidae, and Simuliidae. At tract stations, Ceratopogonidae, Nematoda, Baetidae, Plecoptera, and Oligochaeta were most abundant. In Yellow Creek, Oligochaeta, Ceratopogonidae, Acari, Chironomidae, Nematoda, and Simuliidae were present in greatest abundance. In the White River the most abundant taxa during both sampling periods belonged to the Chironomidae, Ephemerellidae, Tricorythidae, Oligochaeta, Plecoptera, and Simuliidae.

2.4.6 Sediment Chemistry

2.4.6.1 Objectives

The objectives of the sediment chemistry studies remain unchanged from Progress Report 2. See section 2.4.6.1 of Progress Report 2 for specific objectives.

2.4.6.2 Methods

With the exception of analysis for arsenic which consists of a digestion procedure (EPA, 1973) followed by colorimetric analysis according to APHA (1971), no change in methods has occurred since Progress Report 3. See section 2.4.1.2 and 2.4.6.2 of Progress Reports 2 and 3, respectively, for specific methods used for sediment chemistry studies.

2.4.6.3 Results

Table 2.4-5 presents the results of chemical analyses of sediment samples taken during the May - June sampling period.

2.4.7 Macrophytes

2.4.7.1 Objectives

No change in objectives has occurred since Progress Report 3. See section 2.4.7.1 of Progress Report 3 for specific objectives.

2.4.7.2 Methods

No change in methods has occurred since Progress Report 2. See section 2.4.7.2 of Progress Report 2 for specific methods.

2.4.7.3 Results

Aquatic macrophytes were observed at Stations 2, 5, 8, 14, 19, and 20 during May - June. Evaluation of the relative

Table 2.4-5 Results of sediment herbicide analysis. RBOSP Aquatic Baseline Studies. May - June 1975. (Results are presented in μg/g.)

Station	Parameter	
	Tordon 22K	Silvex
1-A	<0.02	<0.02
1-B	<0.02	<0.02
2-A	<0.02	<0.02
2-B	<0.02	<0.02
3-A	<0.02	<0.02
3-B	<0.02	<0.02
4-A	<0.02	<0.02
4-B	<0.02	<0.02
5-A	<0.02	<0.02
5-B	<0.02	<0.02
6-A	<0.02	<0.02
6-B	<0.02	<0.02
7-A	<0.02	<0.02
7-B	<0.02	<0.02
8-A	<0.02	<0.02
8-B	<0.02	<0.02
9-A	<0.02	<0.02
9-B	<0.02	<0.02
13-A	<0.02	<0.02
13-B	<0.02	<0.02
14-A	<0.02	<0.02
14-B	<0.02	<0.02
19-A	<0.02	<0.02
19-B	<0.02	<0.02
20-A	<0.02	<0.02
20-B	<0.02	<0.02
21-A	<0.02	<0.02
21-B	<0.02	<0.02
22-A	<0.02	<0.02
22-B	<0.02	<0.02
23-A	<0.02	<0.02
23-B	<0.02	<0.02
24-A	<0.02	<0.02
24-B	<0.02	<0.02
25-A	<0.02	<0.02
25-B	<0.02	<0.02

Stations 10-12 and 15-18 were dry at the time of sampling.

Table 2.4-5 (Continued)

Station	Parameter Tordon 22k	 Silvex
26-A	<0.02	<0.02
26-B	<0.02	<0.02
27-A	<0.02	<0.02
27-B	<0.02	<0.02
28-A	<0.02	<0.02
28-B	<0.02	<0.02
29-A	<0.02	<0.02
29-B	<0.02	<0.02
30-A	<0.02	<0.02
30-B	<0.02	<0.02
31-A	<0.02	<0.02
31-B	<0.02	<0.02
32-A	<0.02	<0.02
32-B	<0.02	<0.02
33-A	<0.02	<0.02
33-B	<0.02	<0.02
34-A	<0.02	<0.02
34-B	<0.02	<0.02
35-A	<0.02	<0.02
35-B	<0.02	<0.02

abundance of aquatic macrophytes followed the system of Jessen and Lound (1962). At Station 1, the density of water cress (Rorippa nasturtium - aquaticum) was sparse. At Station 5, the density of water cress was sparse, whereas the densities of Ranunculus cymbalaria were moderate. At Station 8, the density of water cress was scattered (it occurred along a strip 12 - 18 inches wide extending approximately 19 feet along the west bank of the stream). At Station 14, Zannichelia vulgaris was present in moderate abundance. At Station 19 (a pond), Chara kieneri was dense. At Station 20, Zannichelia palustris L. was present in scattered abundance.

2.4.8 Fish

2.4.8.1 Objectives

The objectives of fish studies remain unchanged from Progress Report 2.

2.4.8.2 Methods

The high flow and swift current encountered in the White River during the May - June 1975 sampling necessitated some modification in fish sampling procedures. Fishing methods used during the May - June sampling are outlined below.

Station 23

Electroshocking runs were made downstream through a 100 foot (30.5m) section which was not blocked off. Fish were collected with three dip nets. This procedure was then repeated for the second replicate.

Station 25 and 31

Electroshocking from a boat was attempted at these mid-stream stations. These efforts proved unsuccessful as no fish were captured with this method.

Station 27 and 28

Electroshocking runs were made downstream through a 100 foot section (30.5m) using three dip nets to collect fish. (The section could not be blocked off prior to shocking.) The procedure was repeated for the second replicate.

Station 29

Electroshocking runs were made downstream through a 100 foot (30.5m) section using three dip nets to collect fish; also electroshocked upstream along a 40 foot channel adjacent to the stream (neither of these sections could be blocked off). The procedure was then repeated for the second replicate.

Station 30 and 32

Electroshocking runs were made downstream through a 100 foot (30.5m) section using four dip nets to collect fish. The procedure was then repeated for the second replicate.

Station 33 and 34

Electroshocking runs were made downstream through a 100 foot (30.5m) section using three dip nets to collect fish. The procedure was then repeated for the second replicate.

Station 35

Electroshocking runs were made downstream through a 100 foot (30.5m) section from a boat using the two probes and two dip nets from the boat. This procedure was then repeated for the second replicate.

2.4.8.3 Results

During the May - June sampling, approximately 463 fish representing eight species were captured in the White River and lower Yellow Creek. The catch was dominated by rough and forage fishes, with only a single game fish (cutthroat trout) observed. The most abundant fishes were dace, flannelmouth sucker, fathead minnow, and bluehead sucker. The high volume and velocity of flow of the White River hampered fishing efforts during this sampling period. Table 2.4-6 presents fish data from the May - June 1975 sampling period.

2.4.9 Springs and Seepages

2.4.9.1 Objectives

No change has occurred since Progress Report 3. See section 2.4.9 of Progress Report 3 for specific methods.

Table 2.4-6 List of fish species and numbers captured in the White River and lower Yellow Creek. RBOSP Aquatic Baseline Studies. May - June 1975

Common Name	Scientific Name	Number Captured
Cutthroat trout	*Salmo clarki*	1
Fathead minnow	*Pimephales promelas*	43
Dace	*Rhinichthys* spp.	234
Bluehead sucker	*Catostomus discobolus*	36
Flannelmouth sucker	*Catostomus latipinnis*	127
Mottled sculpin	*Cottus bairdi*	11
Roundtail chub	*Gila robusta*	10
Carp	*Cyprinus carpio*	1

2.4.9.2 Methods

No change in methods has occurred since Progress Report 3. See section 2.4.9 of Progress Report 3 for specific methods.

2.4.9.3 Results

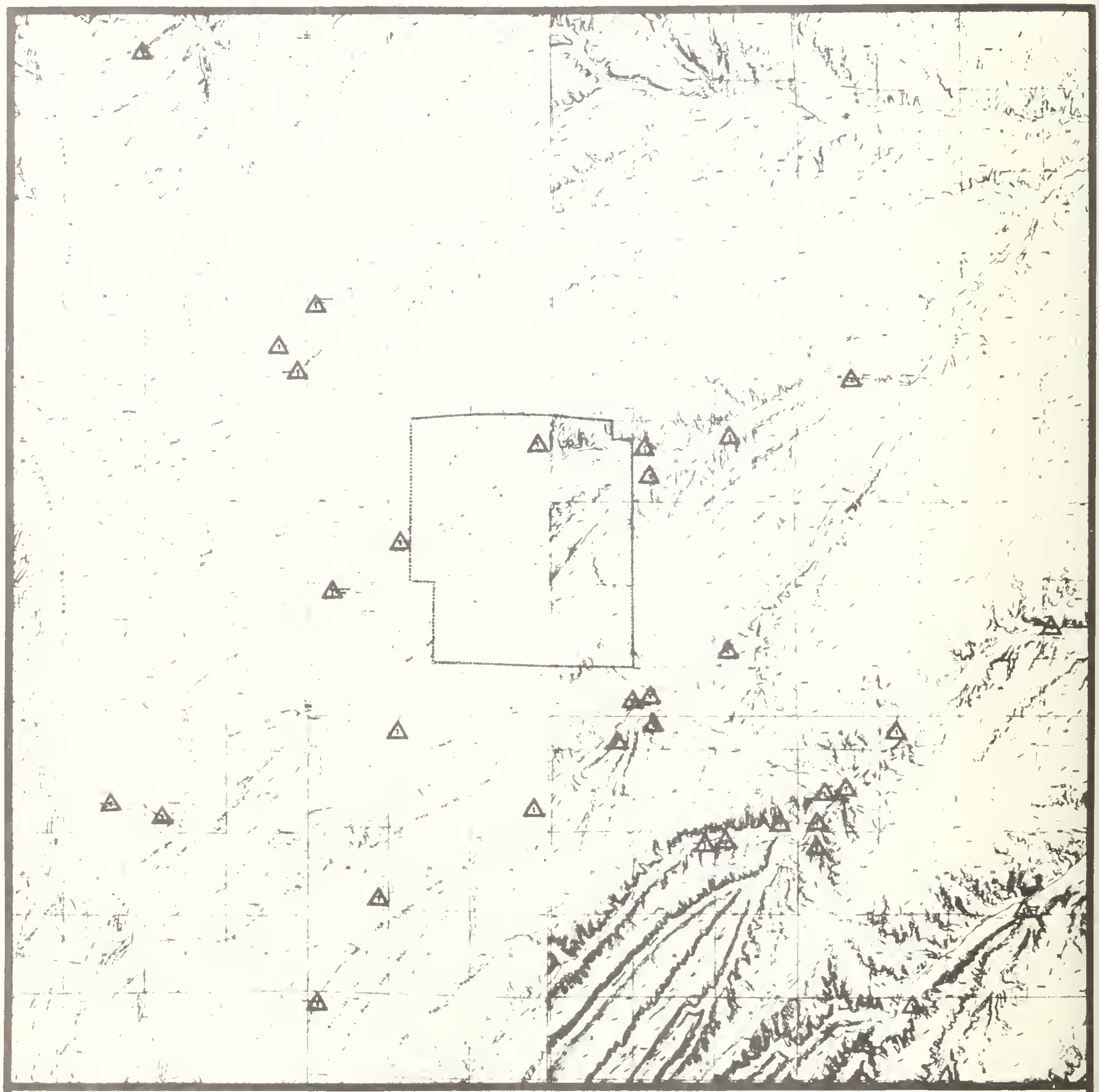
Locations of springs and seepages on or near Tract C-a are shown on Figure 2.4-2. Additional springs and seepages which are not identified on Figure 2.4-2 include:

- a series of seepages located from 25 to 200 feet above aquatic sampling Station 4 in Water Gulch
- Maverick Springs at aquatic sampling Station 3 in Corral Gulch
- a spring located approximately one mile above the confluence of Water and Corral Gulches
- a spring located approximately 100 feet above aquatic sampling Station 9 in Corral Gulch
- a spring located approximately one mile above the confluence of Water and Corral Gulches
- a spring located approximately 1300 feet above aquatic sampling Station 14 in Corral Gulch
- a spring at aquatic sampling Station 2 in Spruce Gulch
- a spring at aquatic sampling Station 1 in Cross Gulch approximately two miles above the confluence with Spruce Gulch
- a spring located approximately 2600 feet above aquatic sampling Station 1
- a spring located approximately 50 feet above aquatic sampling Station 8 in Box Elder Gulch
- a spring located immediately above aquatic sampling Station 8 in Box Elder Gulch
- a spring located approximately 50 feet above aquatic sampling Station 2 in Spruce Gulch
- a spring located approximately 1300 feet west of aquatic sampling Station 13 on Corral Gulch
- a seepage in Stake Springs Draw approximately 200 feet above its confluence with Corral Gulch

2.4.10 Hydrology

2.4.10.1 Objectives

The objective of this segment of the aquatic program is to measure the approximate stream velocites at each site at the time of sample collection to assist in characterizing the existing aquatic habitat.



ENVIRONMENTAL
STUDIES FOR THE
RIO BLANCO OIL SHALE PROJECT

TRACT C-a

LIMNETICS, INC.
Denver, Colorado

5/75

SPRING & SEEPAGE LOCATIONS

△ springs and seepages as of 5/75

Figure 2.4-2

N

MILES
0 1/2 1 2

2.4.10.2 Methods

Stream velocity is measured at each sampling site with Gurley flowmeters or an equivalent device.

2.4.10.3 Results

The approximate stream velocities during the May - June sampling period are presented in Table 2.4-7.

2.4.11 Miscellaneous Studies

2.4.11.1 Objectives

No change in objectives has occurred since Progress Report 3. See section 2.4.11 of Progress Report 3 for specific objectives.

2.4.11.2 Methods

No change in methods has occurred since Progress Report 3. See section 2.4.11 of Progress Report 3 for parameters included in these studies.

2.4.11.3 Results

Data from the May - June sampling period are included in Table 2.4-8.

Table 2.4-7 Stream flows observed during RBOSP Aquatic Baseline Studies. May - June 1975

Station	Flow (ft/sec)
1	1.5
2	2.5
3	0.9
4	1.4
5	1.4
6	3.5;2.0
7	2.5
8	3.2;1.8
9	1.7
13	1.7
14	0.0
19	1.8
20	1.4
21	2.3
22	0.0
23	2.1;0.2
24	4.4;3.0
25	7.5
26	4.6;3.0
27	1.6;1.2
28	3.3;0.8
29	5.8;3.1
30	5.3
31	6.7
32	3.9;1.5
33	3.5
34	3.5
35	4.0;3.1

---

[1] Stations 10 - 12 and 15 - 18 were dry at the time of sampling.

Table 2.4-8 Water quality data. RBOSP Aquatic Baseline Studies. May - June 1975. (Data are expressed in mg/l unless otherwise noted.)

Parameter	Station Replicate			
	25		34	
	A	B	A	B
Arsenic (As), Diss	< 0.03	< 0.03	< 0.03	< 0.03
Barium (Ba), Diss	< 0.1	< 0.1	< 0.1	< 0.1
Boron (B) Diss	< 0.5	< 0.5	< 0.5	< 0.5
Cadmium (Cd), Diss	< 0.01	< 0.01	< 0.01	< 0.01
Chromium (Cr) Total Diss	< 0.03	< 0.03	< 0.03	< 0.03
Copper (Cu), Diss	< 0.02	< 0.02	< 0.02	< 0.02
Cyanide (Cn) Total	< 0.001	< 0.001	< 0.001	< 0.001
Fluoride (F), Diss	0.07	0.07	0.06	0.06
Iron (Fe), Total Diss	0.03	0.06	0.05	0.05
Lead (Pb) Diss	< 0.05	< 0.05	< 0.05	< 0.05
Lithium (Li) Diss	< 0.02	< 0.02	< 0.02	< 0.02
Manganese (Mn), Diss	< 0.02	< 0.02	< 0.02	< 0.02
Mercury (Hg), Diss (ug/l)	0.8	0.6	0.8	0.6
Phosphorus (P), Total Diss	0.02	0.02	0.02	0.03
Selenium (Se), Diss	< 0.01	< 0.01	< 0.01	< 0.01
Solvent extract (Oil)	0.025	< 0.006	< 0.006	0.037
Sulfate (S), Diss	16	16	15	16
Sulfide (S), Diss	< 0.02	< 0.02	< 0.02	< 0.02
Zinc (Zn), Diss	< 0.02	< 0.02	< 0.02	< 0.02

Diss = Dissolved

2.5 Other Environmental Programs

2.5.1 Soils Survey and Productivity Assessment Studies

2.5.1.1 Objectives

The soil studies are designed to fulfill the requirements of the oil shale lease, provide data necessary in the determination of ecosystem relationships and provide information required during revegetation studies.

The objectives of the soil survey are to describe and map soil types. Soil types, depths of the various layers of soil, strike and dip of the soil, slopes, vegetation cover and erodibility are described.

Consult Progress Report 2, Section 2.5.1.1 for additional objectives of the soils program.

2.5.1.2 Methods

Methods employed in the soil studies are described in Section 2.5.1.2 of Progress Report 2.

2.5.1.3 Results

Preliminary soil surveying and mapping has been carried out by the Soil Conservation Service (SCS). A preliminary soils map has been prepared by the SCS and is currently undergoing further revisions. A general description of the twelve soil types encountered during surveying and mapping by the SCS are discussed below.

The aridic haploboroll, loamy-skeletal, mixed, unnamed series consists of moderately deep, well-drained soils that formed in colluvium on foothill sideslopes. These soils have slopes of 12 to 50 percent. Mean annual precipitation is about 46 cm (18 inches), and the mean annual temperature is about 5 to 6 C (42 F). The typical pedon is channery loam, 12 to 60 percent slopes, SW1/4 NW1/4 Section 10, T1N, R99W.

The Forelle series consists of deep, well-drained soils that formed in calcareous aeolian sediments. Forelle soils are on uplands and terrace slopes and have slopes of 3 to 15 percent. Mean annual precipitation is about 35 to 46 cm (14 to 18 inches), and mean annual air temperature is about 5 to 6 C (42 F). Forelle soils are similar to the Piceance and Yamac soils. Piceance soils have a lithic contact less than

100 cm (40 inches). Yamac soils do not have an argillic horizon. Typical pedon of Forelle loam, 3 to 25 percent slopes, about 0.5 km (0.3 mile) east and 0.3 km (0.2 mile) south of the northwest corner of Section 30, T1N, R93W.

The Glendive series consist of deep, well-drained soils formed in alluvial materials. Glendive soils are in valley positions and have slopes of 2 to 9 percent. Mean annual precipitation is about 35 cm (14 inches), and mean annual air temperature is about 5 C (43 F). Glendive soils are near the Hagga, Havre and Hanly soils. Hagga soils are poorly drained; Hanly soils have a sandy control section; and Havre soils are finer textured than the Glendive soils. Typical pedon of Glendive fine sandy loam, 2 to 9 percent slopes, about 90 m (100 yards) south of the Ryan Gulch Road and 15 m (50 feet) east of the fence in the NE1/4 of NE1/4 Section 12, T2S, R98W.

The Hagga series consists of deep, very poorly-drained soils that formed in alluvium derived mainly from calcareous sandstones and shales. Hagga soils are on valley bottoms and have slopes of 0 to 5 percent. The mean annual precipitation is about 40 cm (16 inches), and the mean annual temperature is about 7 C (45 F). Hagga soils are similar to the Buford and Havre soils. Buford soils have dark surfaces and have very gravelly substrata. Havre soils are well drained to moderately well drained, lacking mottles above a depth of 100 cm (approximately 40 inches). Typical pedon of Hagga loam, 0 to 5 percent slopes, 45 m (150 feet) south and 49 m (160 feet) west of northwest corner of Section 5, T3S, R96W 53m (175 feet) southwest of Stuart Gulch gaging station).

The Hanly series consists of deep, somewhat excessively drained soils that have formed in detrital alluvium of calcareous sandstone and shale origin. Hanly soils are on alluvial fans and in narrow valleys with slope gradients of 2 to 9 percent. Mean annual precipitation is about 15 cm (6 inches), and the mean annual air temperature is about 7 C (45 F). Hanly soils are similar to the Glendive soils with which they are closely associated. Glendive soils differ in being mainly sandy loam at 25 to 100 cm (approximately 10 to 40 inch) depths. Typical pedon of Hanly gravelly loamy fine sand, 2 to 9 percent slopes, 2.4 km (1.5 miles) up Ryan Gulch, 60 m (200 feet) north of road, in the SE1/4 of SE1/4 Section 31, T1S, R98W.

The Havre series consists of deep, well-drained soils that formed in calcareous mixed alluvium. Havre soils are on floodplains and low terraces and have slopes of 0 to 8 percent. Mean annual precipitation is about 40 cm

(16 inches), and the mean annual air temperature is about 6 to 7 C (44 F). Havre soils are similar to Uffens, Glending, Youngston, Hagga, Hanly and Glendive. Uffens soils are natric and saline in reaction. Glending and Youngston occur in a warmer temperature zone. Glending, Hanly and Glendive have sandier control sections. Hagga soils are poorly drained. Typical pedon of Havre loam, 0 to 8 percent slopes, 0.6 km (0.4 mile) south, 60 m (200 feet) east of the NW corner of Section 32, T1N, R94W.

The lithic haploboroll, loamy-skeletal, mixed, unnamed series consists of shallow, well-drained soils that formed in sandstone residuum on upland slopes and ridge tops. These soils have slopes of 5 to 50 percent. Mean annual precipitation is about 46 cm (18 inches), and the mean annual air temperature is about 5 to 6 C (42 F). The typical pedon is very channery loam, 5 to 50 percent slopes, NE1/4 NW1/4 Section 22, T1N, R99W.

The Piceance series consists of moderately deep, well-drained soils that formed in residuum from sandstone and modified with aeolian material. Piceance soils are on upland slopes and ridges and have slopes of 5 to 15 percent. Mean annual precipitation is about 35 to 46 cm (14 to 18 inches), and the mean annual air temperature is about 6C (43 F). Piceance soils are similar to Forelle, Yamac and Kinnear. Forelle, Yamac and Kinnear soils are deep and do not have bedrock above 100 cm (approximately 40 inches). Kinnear soils occur in a warmer temperature zone. Typical pedon of Piceance fine sandy loam, 5 to 25 percent, NE1/4 of NE1/4 Section 33, T2S, R99W.

The Redcreek series consist of shallow, well-drained soils that formed in sandy material weathered from underlying calcareous sandstone. Redcreek soils are on mountain sideslopes and ridges and have slopes of 5 to 30 percent. Mean annual precipitation is about 40 cm (16 inches), and the mean annual air temperature is about 6 to 7 C (44 F). Redcreek soils are similar to the Rentsac soils. Rentsac soils are skeletal and are on fractured sandstone, while Redcreek soils are non-skeletal and are on massive sandstone. Typical pedon of Redcreek sandy loam, 5 to 30 percent slopes, about 275 m (900 feet) N to SW1/4 corner, Section 18, Township 3 South, R96W.

The Rentsac series consists of shallow, well-drained soils formed in residuum from sandstone. Rentsac soils are on foothills (upland entrenched terrace) and have slopes which are 5 to 50 percent. Mean annual precipitation is 40 cm (approximately 16 inches), and the mean annual air temperature is about 6 to 7 C (44 F). Rentsac soils are similar to the Redcreek soils. Redcreek soil is non-skeletal, while Rentsac is skeletal. Typical pedon of Rentsac very channery sandy loam, 5 to 50 percent slopes, under chained pinyon-juniper area, NE1/4 SW1/4, Section 27, Township 1 North, R98W.

Rock outcrop-Torriorthents, 12 to 90 percent slopes (RT) occurs mainly on southerly aspects in the Piceance Basin on strongly sloping to extremely steep terrace breaks of the many drainageways of this area. Rock outcrop occurs as horizontal sandstone cliffs or dike-like outcrops and as platy siltstone outcrops in 50 to 65 percent of the mapping unit. The remainder of the mapping unit is comprised of Torriorthents, most of which are very shallow and shallow, and a small percentage of moderately deep and deep Torriorthents in the colluvial and alluvial material. The vegetation is characteristically very sparse - few scattered pinyons, junipers and shrubs. These soils have a severe limitation for sanitary facilities and local roads due to shallowness of the soil. These soils are a poor source of material for roadfill and topsoil due to thin layer, small stones and problems of area reclamation.

The Yamac series consists of deep, well-drained soils that formed in alluvium and aeolian materials. Yamac soils are on rolling uplands and ridges and have slopes of 5 to 15 percent. Mean annual precipitation is about 36 cm (14 inches), and mean annual air temperature is about 6 to 7 C (44 F). Yamac soils are similar to the Forelle and Piceance soils. Forelle soils have an argillic horizon not found in the Yamac. Piceance soils overlie bedrock at 50 to 100 cm (approximately 20 to 40 inch) depths. Typical pedon of Yamac loam, 5 to 15 percent slopes, SW1/4 of Section 2, T2S, R99W.

The SCS is processing soils for trace element and mechanical analysis.

The selection of a soils contractor is currently being made and the initiation of the program will be started immediately upon contract award. This program will include collection and analysis of soil samples associated with major vegetation types. Trace metal concentrations will be determined and soil/ plant relationships will be interpreted.

2.5.2 Archaeological Survey

2.5.2.1 Objectives

The archaeological survey was designed to locate archaeological or historical material on Tract C-a, a mile-wide perimeter around the tract and 84 Mesa. The survey was then extended downstream on several drainages, particularly Yellow Creek, to obtain more information on off-tract sites.

The survey was designed to obtain information on the extent of occupation, cultural affiliations, time depth represented and native exploitation of the region. Material found during this study was compared with that described from other areas, particularly the Douglas Creek drainage.

Comparison of artifacts found on Tract C-a was also made with collections held by local individuals, many of whom have been collecting artifacts from the area for many years. The procedure prevented inadvertent omission of scarce or commonly sought after items such as projectile points (arrowheads).

The past existence of trade relationships between local inhabitants and those from areas outside the basin was explored. Evidence that trade had been conducted was revealed by the presence of pottery that had not been locally made and the presence of imported toolstone. These artifacts suggested a widespread contact with areas outside the Piceance Basin.

2.5.2.2 Methods

Two types of ground surface surveys were employed during the investigations No excavations were done. Both surveys involved systematic walk-overs of the area and collection of artifacts. The following data were recorded for each located collection: field number and distinctive features of the site (such as terrain or structures). Each find was labeled and kept separate from others.

In rough or borken ground, areas that could have been occupied such as benches adjacent to drainages, areas near springs or streams and upland areas that might have been used for hunting or gathering camps were intensively searched. Areas that have produced artifacts in the past were also carefully searched.

In relatively featureless terrain such as 84 Mesa and the alluvial valley floors, team members were spaced a short distance and the area was systematically traversed with team members searching for artifacts.

When artifacts were found, the team then concentrated on that area and collected as much material as could be located. The search was continued until no more artifacts or chips were found.

After early surveys had progressed sufficiently, information gathered in the field was processed. Types of artifacts obtained and the locations of sites were itemized and mapped, and the emerging pattern of site locations was used to direct the investigation into areas in which the probability of finding additional sites was greatest. This technique prompted surveying down into the more productive lower drainages rather than moving up the drainages toward the less productive Cathedral Bluffs. While the high uplands were probably utilized to some extent, the majority of camp locations were on lower ground.

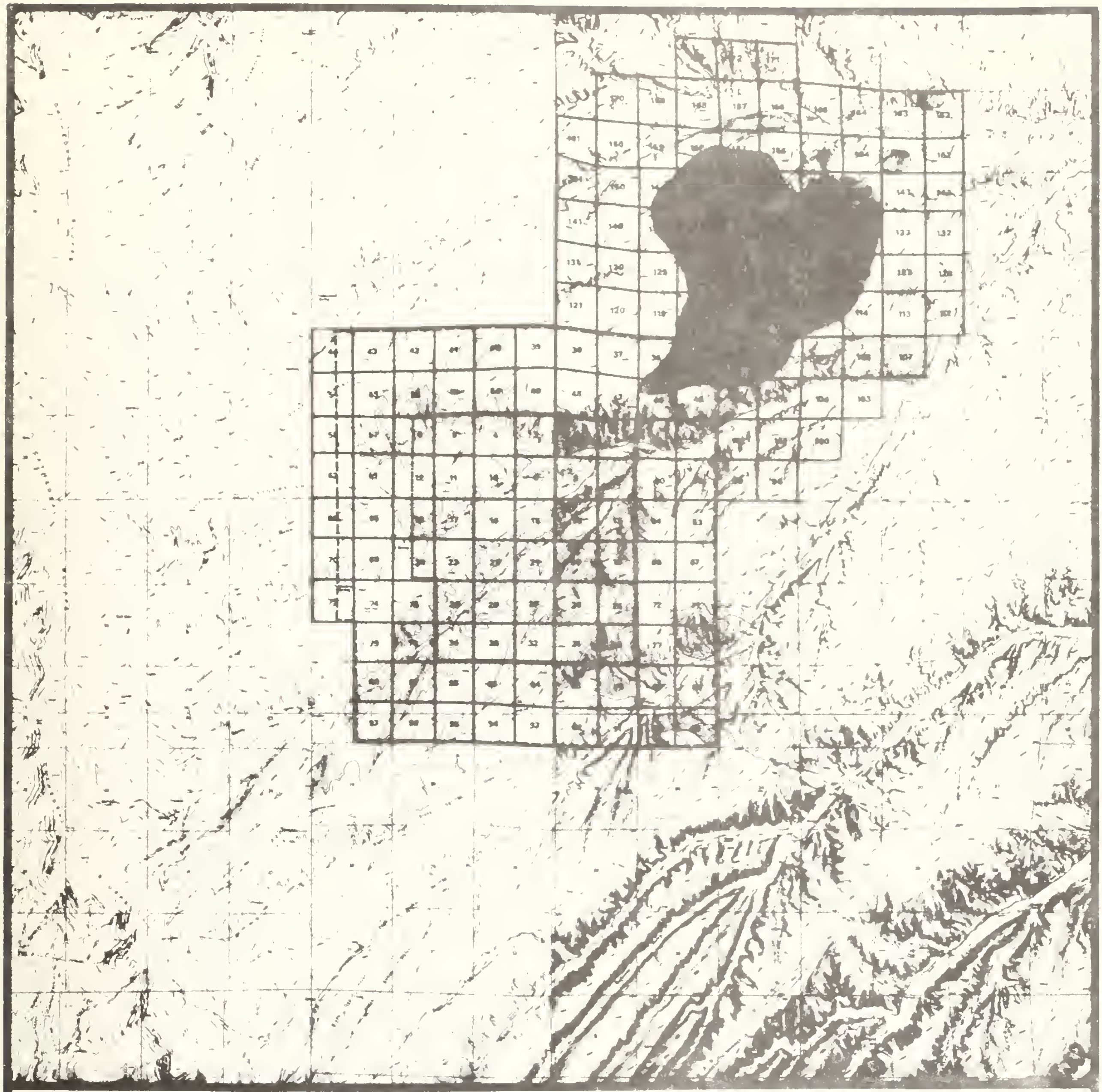
Material recovered in the field was processed in the base station laboratory. Artifacts were washed, labeled with field numbers, identified and recorded. Both site locations and non-productive areas were plotted at the end of each field day.

The initial survey followed the priority system delineated in Figure 2.5.2-1. After this area had been cleared for the presence or absence of sites, the survey was expanded to the areas shown in Figures 2.5.2-2, 3 and 4.

In addition to surveys and collections on site, several private collections and museums in Meeker and Dinosaur National Monument were inspected to provide additional background on the archaeological history of the area. A number of caves and overhangs which offered protection and were probable wintering areas for people who utilized the Piceance Basin are found in the Douglas Creek area. One of the most distinctive features of shelters in the Douglas Creek drainage is the amount of rock art. It includes pictographs painted on the walls and petroglyphs which are not painted but are pecked into the rock face. These include depictions of humans, various animals and designs. A similar area with three caves north of Rangely was also inspected.

2.5.2.3 Results

A total of 196 locations produced material that was transported into the area, or modified, by man. These ranged from a single flake of toolstone to concentrations of tools, broken or discarded pieces and wastage associated with the manufacture of tools. The material used for chipped tools included



ENVIRONMENTAL STUDIES FOR THE RIO BLANCO OIL SHALE PROJECT

TRACT C-a

LIMNETICS, INC.
Denver, Colorado

4/75

ARCHEOLOGICAL SURVEY

999	indicates priority for performance and reporting requirements
■	84 Mesa spent shale disposal site
---	one mile perimeter of Tract

SURVEYS COMPLETED AS OF JUNE 30, 1975

N

MILES
0 1 2

Figure 2.5.2–1

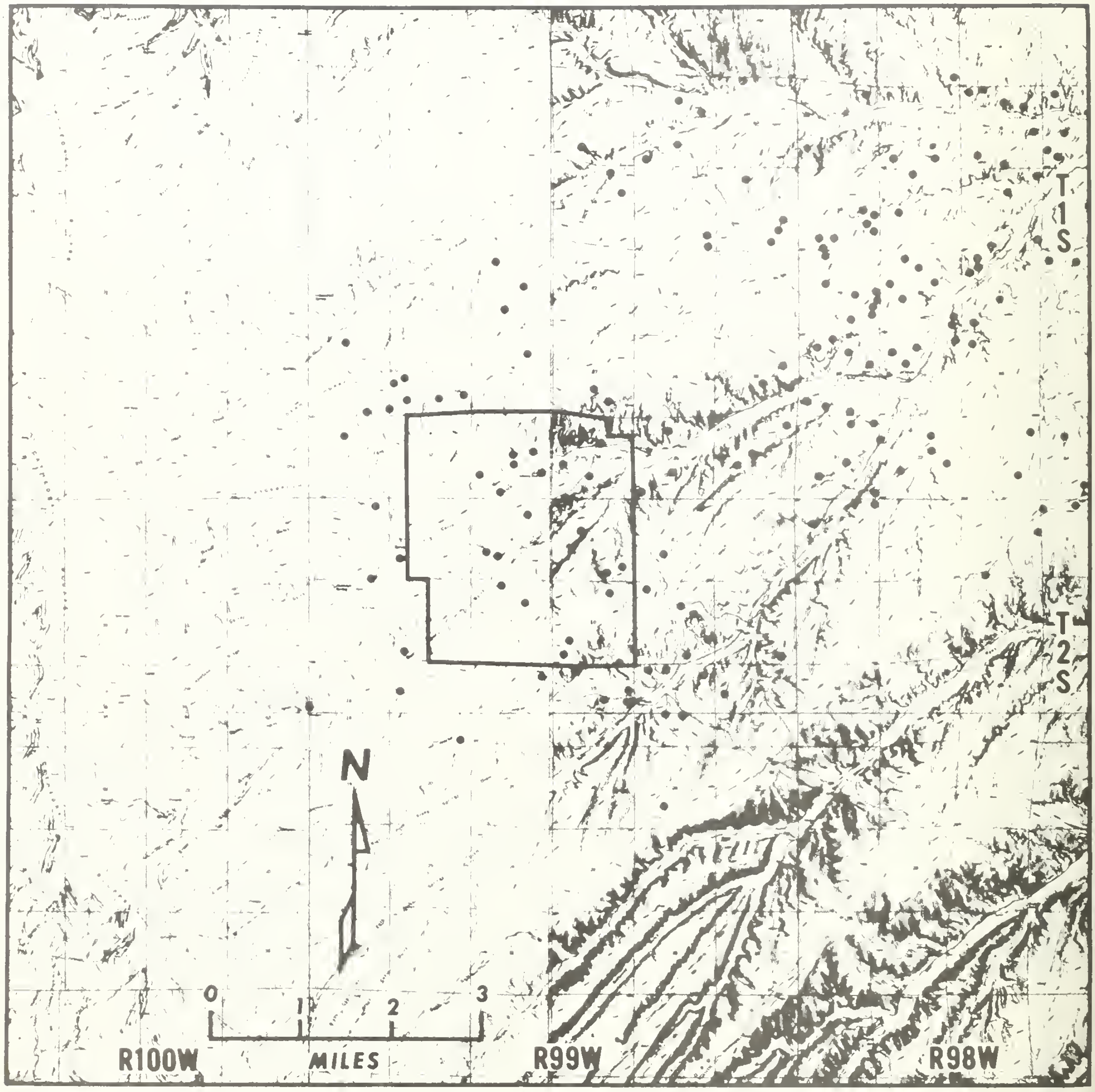


Figure 2.5.2–2

Locations of Artifacts Found on and Adjacent to Tract C-a, RBOSP. Summer 1975

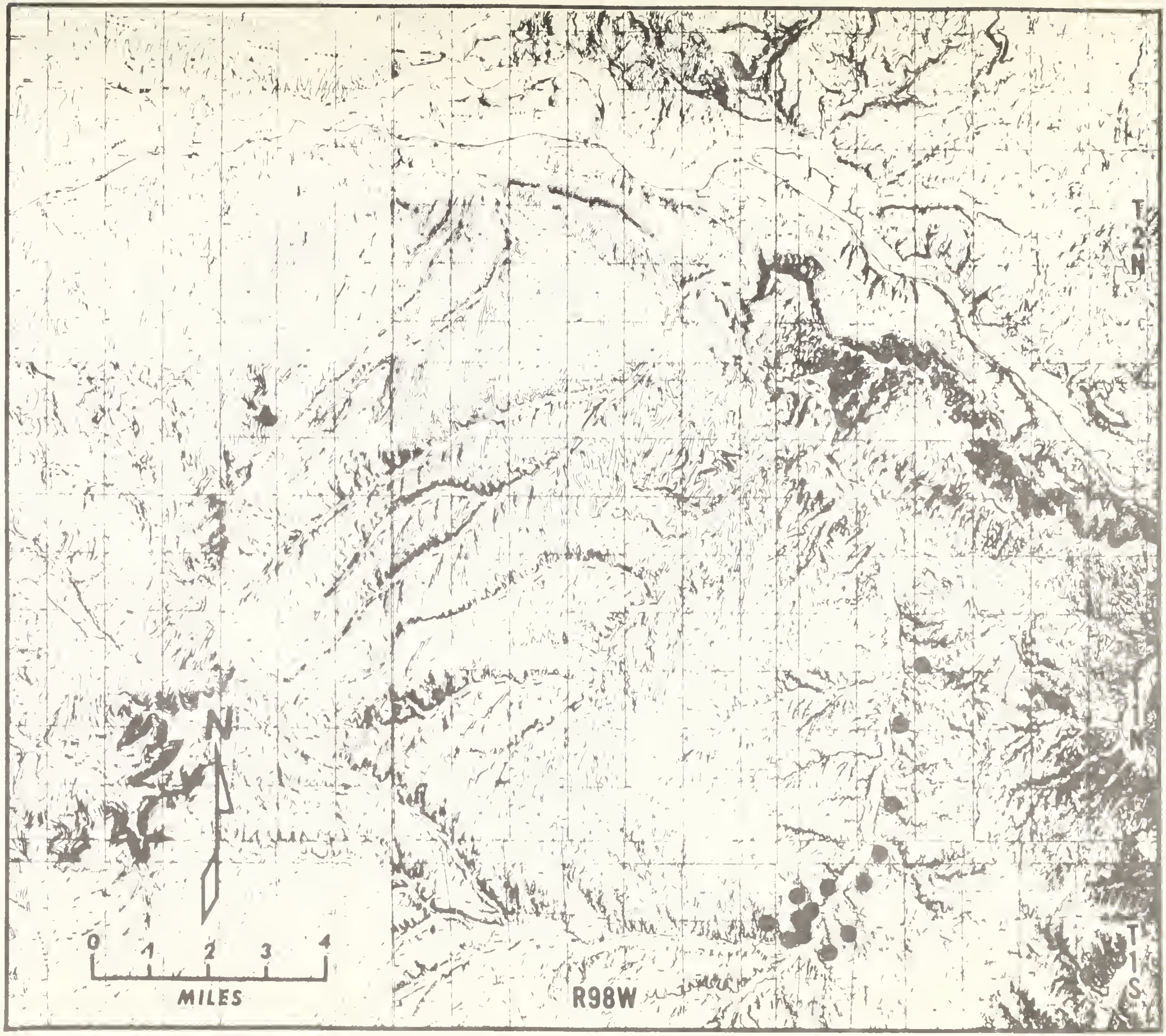


Figure 2.5.2–3 Yellow Creek Drainage Survey Area. Dots Represent Locations of Artifacts.

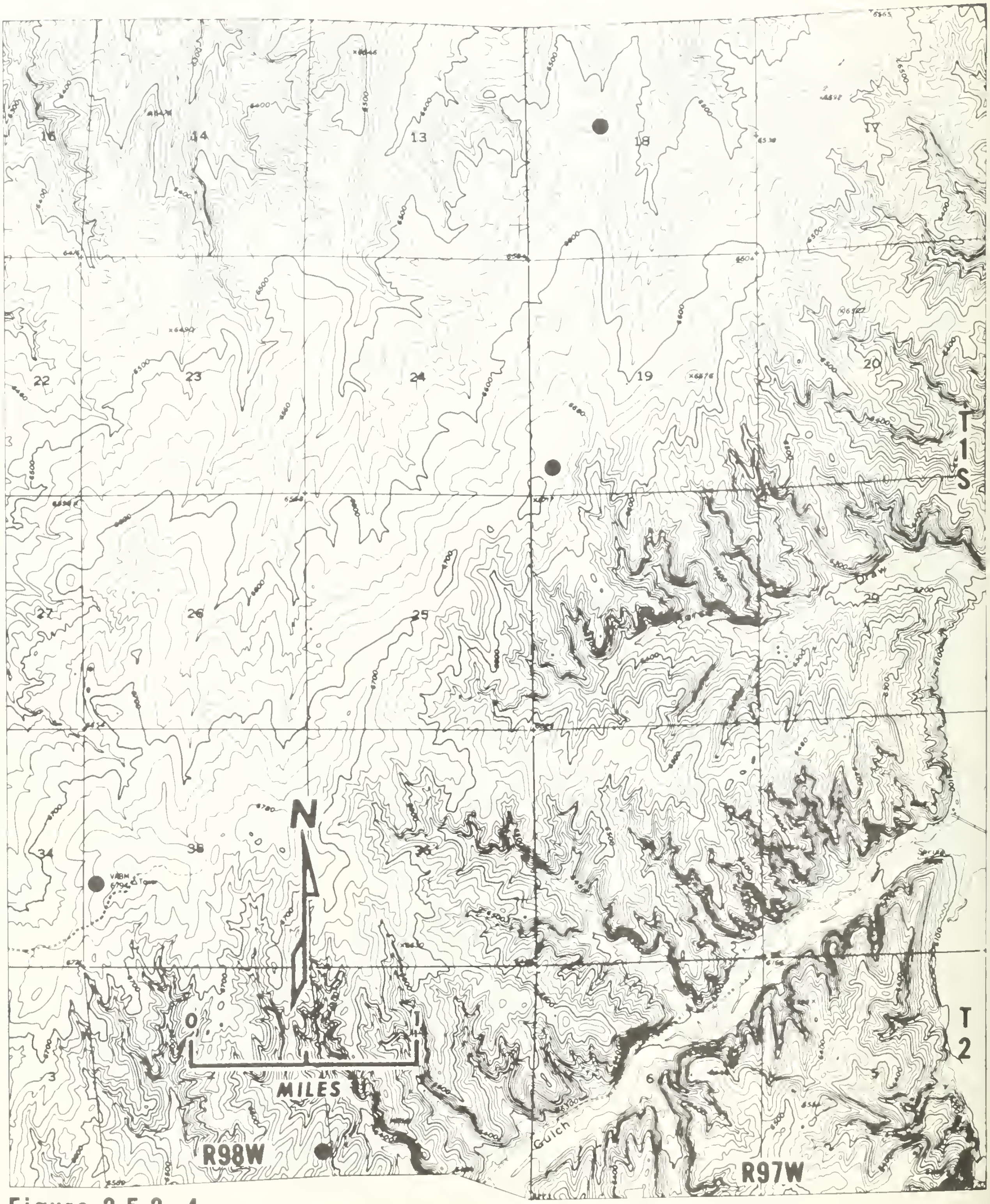


Figure 2.5.2–4
Drainage Survey Area. Dots Represent Locations of Artifacts.

chalcedony, jasper, petrified wood, obsidian and quartzite. These materials are fine grained and were worked by flaking. During tool production, small chips were often discarded if they were too small to serve as secondary tools. This wastage is usually a good indication that an area was once occupied. The color and texture of small tools or flakes found in the study area were quite different from the local shales and sandstones. Since the local stone cannot be worked to produce functional small tools, it is likely that toolstone was imported by the inhabitants. There was some use of local stone for larger tools such as choppers and grinding stones. Suitable toolstone supplies are present in the main White River drainage, west into Utah, and in southwestern Wyoming. No quarry sources for toolstone were found during the survey.

Tools used for grinding various vegetal products were also found in the area. The lower element of these tools, the grinding slab, was usually an oval or irregular slab of local sandstone characterized by a depression that had been formed through long use. The handstone, or moveable element, was fashioned from a thin, oval stream cobble. These were of a size that could conveniently be held in one hand. Evidence from this historic period indicates that these tools were used to grind various types of seeds, to hull pinyon nuts, and even in some instances to grind dried meat. Cooking techniques during this period included preparation of liquid or mush foods. Another use of these tools was to grind pigments that could have been used for body painting, decoration of portable objects or painting of pictographs.

The sites that were found in the survey are classed as open sites. Open sites are located in areas in which there is no physical protection other than variations in the terrain. Few caves or overhangs were found, and those investigated did not appear to have been occupied. Camping in the open, which would suggest good weather, was common. Open sites, however, usually yield few artifacts because organic decay, insect or bacterial action and oxidation quickly destroy all but the most durable artifacts. Those found are lithic or stone artifacts. The samples collected during the survey consisted almost entirely of items made from stone. In prehisotric times, tools were often made of many other materials such as wood, bone, antler, horn and plant products that produced fibers or other useful elements. No artifacts made from these perishable materials were found. Unworked bone is scattered through the area, but this is probably a result of hunting activity and winter kills.

A few pieces of broken pottery were found that may have been imported from the Mesa Verde region or from the west, in Utah, and the northwest, in Dinosaur National Monument.

Several classes of artifacts were collected, including projectile points. These are good diagnostic artifacts,as their shapes and chipping design are regionally and temporally distinctive. Most points in the collection exhibit additional modification for attaching to a weapon shaft, including notching or definite base design to hold the sinew used to tie the point on. Broken points (probably discarded at camp sites and replaced with whole new points) are also part of the collection. Careful workmanship and chipping on all edges and both sides of the point are common to the tools in the collection. Good grade (glassy) toolstone was used.

Two types of projectiles were found (Figure 2.5.2-5). The larger projectiles are classified as dart points used for attachment to a short, spear-like shaft. These weapons were usually thrown from a spear thrower, a weapon approximately 2 inches wide and 18 inches long. The other type of projectile points are much smaller and are classified as arrow points. These would indicate use of the bow and arrow. Use of the bow succeeded use of the spear thrower, although there may have been an overlap in their use.

Knives are defined as processing tools that were chipped on both sides to produce a wedge-shaped cutting edge. These were probably primarly used for cutting meat, working hides and for cutting other materials. Two types of knives were made. One was a finished tool with distinct shapes and dimensions. These were fabricated by chipping both the edges and the faces. The other type of knife was merely a flake which was used until it dulled, then discarded. These flakes have extremely sharp edges, much more so than a chipped knife, but the edges are extremely fragile and not very durable. Although knives could have been used to scrape objects, the wear pattern is similar to that produced on steel knives. Drawings of knives found on Tract C-a are shown in Figure 2.5.2-5 and 6.

Scrapers were used to remove unwanted material from hides and other materials. The edge of a scraper differs from that of a knife in that it was chipped away from the edge, giving it an angular surface. Finished scrapers have one flat side and a rounded or convex upper surface. Chips or flakes were sometimes used as scrapers for a particular task and then discarded. Most of the scrapers found in the survey (Figure 2.5.2-6) were too small to have been attached to a handle and were probably held in the fingers. Flakes, while indicative of occupation, are

Drawings actual size.

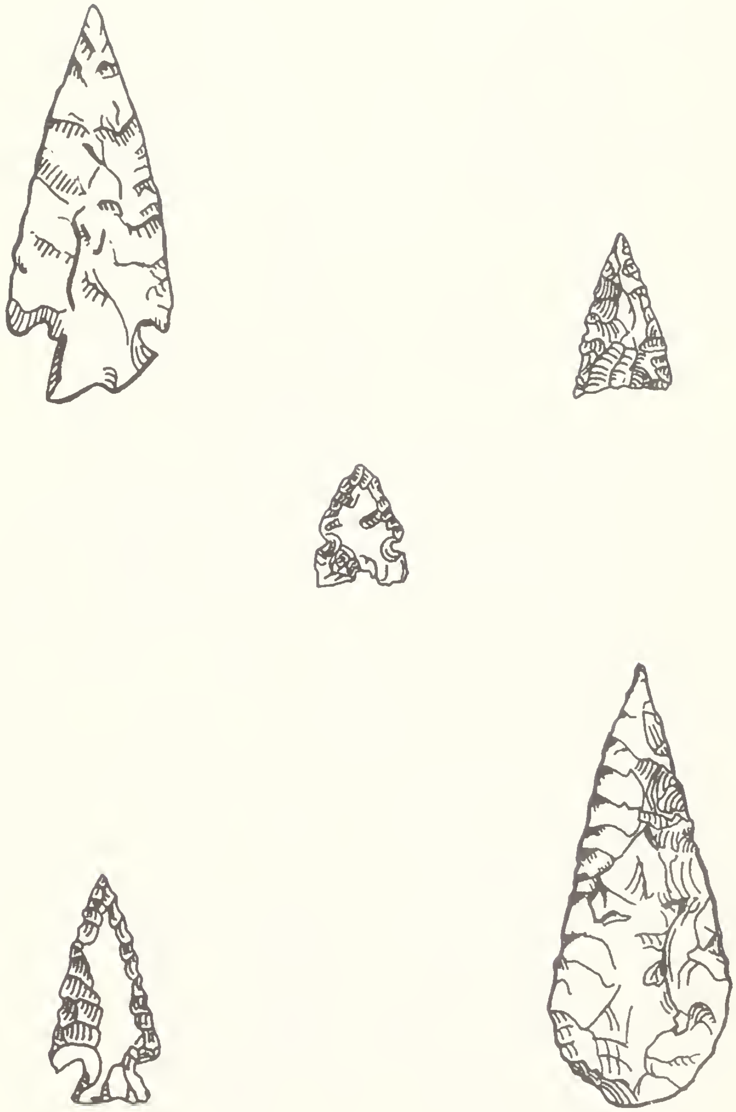


Figure 2.5.2-5 Projectile points and a knife from Tract C-a, RBOSP. Upper right Archaic projectile point, remainder Fremont. Lower right, knife.

Drawings actual size.

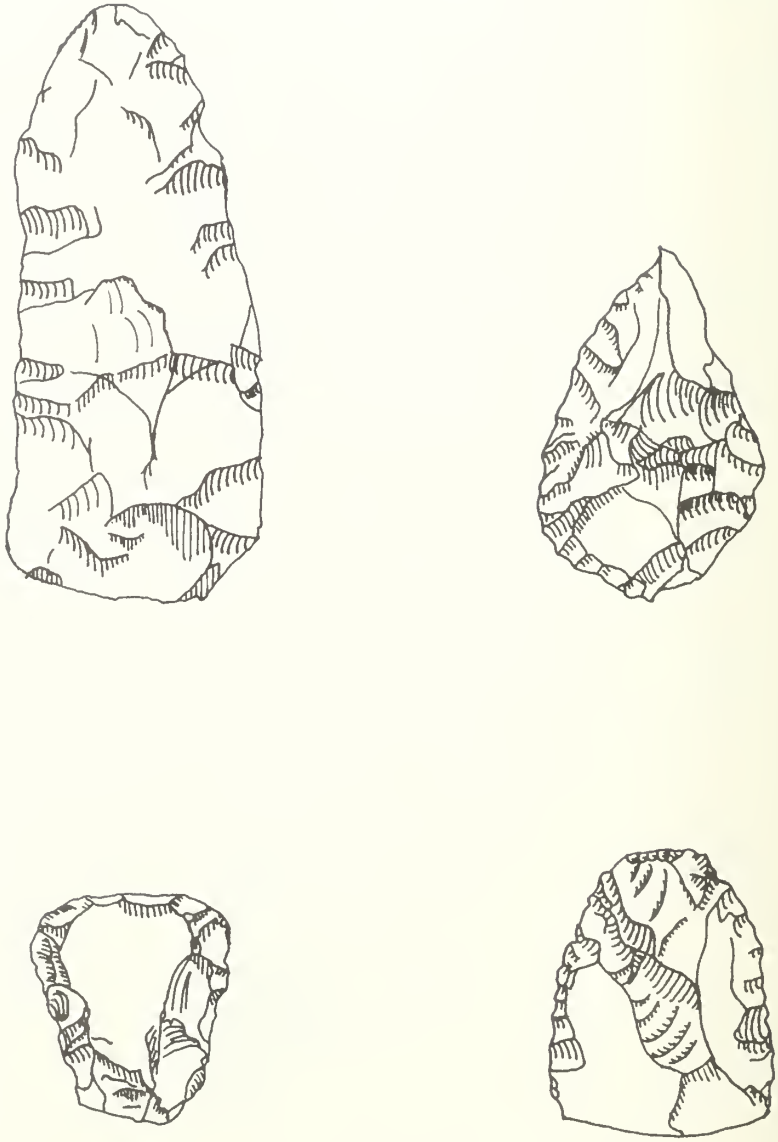


Figure 2.5.2-6 Knives and scrapers from Tract C-a RBOSP.
Upper row knives, lower row scrapers.

usually not good diagnostic artifacts unless they were used secondarily as tools such as knives or scrapers. Unfortunately, they do not aid in temporal or cultural identification, but their abundance and distribution are good indicators of the amount of occupation at a given site.

Metates (grinding slabs) and manos (handstones) were used for grinding food to a meal or powder. Drills and punches are similar tools to ones in our culture, except that they were made of stone. Cores are the remnants of toolstone from which flakes have been removed. They are not usually tools in themselves. Hammerstones are more or less spherical pieces of tough stone that were used to fabricate or process other materials. Hammerstones were used to shape manos and metates. Choppers are large chipped-edge tools that were used to chop or part various materials. They could have been used in butchering, coarse fabrication, or working any non-stone material.

The initial list of tool types and site locations is shown in Tables 2.5.2-1 through 2.5.2-4 for Tract C-a, the 1-mile perimeter, 84 Mesa and off-tract sites.

Sites yielding a concentration of tool wastage and artifacts were called lithic scatters. These represent some permanence of occupancy, at least long enough to produce, lose or discard the materials found. These areas may have been used intensively during a short period of time or may represent a camp that was repeatedly used over a period of years. No sites appeared to have been year-round camps, but merely gathering places for utilization of a particular resource. The aboriginal occupation of Tract C-a and the surrounding Piceance Basin was probably seasonal. The Basin was probably not used during the winter and spring because of inclement weather in the winter and poor hunting possibilities in the spring. The combination of hunting tools, meat and skin processing tools, and tools used for the preparation of vegetal materials would suggest that the area was occupied from summer through fall. Scarcity of food probably precludes the presence of large groups of people. The types of tools would suggest two patterns of exploitation that can be interlocked in terms of time. In the late summer and fall, hunting and gathering could have been practiced simultaneously. Hunting was probably performed by men, and gathering by women and children except during highly successful seasons when processing of game and gathering may have been shared. The area was primarily used as a source of game and vegetal products. Good harvests of pinyon nuts probably drew people into the area in some instances. The term "Piceance" locally translated from the Ute as "land of tall grass" may indicate some utilization of grasses,

Table 2.5.2-1 Field site number, site location and initial material culture analysis located June through September 1975 on Tract C-a, RBOSP.

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
4	T2S,	R99W	S3 , NW¼		1f*		3	Metate
5	T1S,	R99W	S34, SW¼ NE¼		1f			
6	T1S,	R99W	S33, SE¼ NW¼	1f	1f			
7	T2S,	R99W	S4 , NW¼ NE¼		1f	2	12	
8	T1S,	R99W	S34, NW¼ SW¼					Punch
9	T1S,	R99W	S33, NW¼ SW¼				3	
14	T2S,	R99W	S4 , NE¼ SE¼			1		
15	T1S,	R99W	S34, SE¼ SW¼				7	Tool fragment
16	T1S,	R99W	S34, SW¼ SW¼			1	2	
29	T2S,	R99W	S4 , NE¼ SE¼					Tool fragment
33	T1S,	R99W	S33, SE¼ SW¼			1f		
34	T1S,	R99W	S33, SW¼ NE¼			1f		
37	T2S,	R99W	S10, NW¼ SW¼	1f				
38	T2S,	R99W	S9 , NW¼ SW¼				1	
39	T2S,	R99W	S10, SW¼ SW¼				2	
40	T2S,	R99W	S10, NW¼ NE¼	1			1	
41	T2S,	R99W	S3 , SE¼ SE¼	1	2f	6	2	Drill
42	T2S,	R99W	S3 , SW¼ SE¼					Metate
43	T2S,	R99W	S9 , NE¼ NW¼					Mano fragment 2 tool fragments
45	T1S,	R99W	S33, NE¼ SE¼	1				
				1f			12	
51	T2S,	R99W	S10, SE¼ SE¼				1	
54	T2S,	R99W	S3 , NW¼ SW¼				3	Core

* Identifiable fragmentary tool

Table 2.5.2-2 Field site number, site location and initial material culture analysis for archaeological sites located June through September 1975 in the 1-mile perimeter of Tract C-a, RBOSP.

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
10	T1S,	R99W	S29, NW¼ SW¼				1	
11	T1S,	R99W	S29, SW¼ SW¼			1	1	
12	T1S,	R99W	S29, SW¼ SE¼			1	4	
13	T1S,	R99W	S29, NW¼ SW¼		1f*		1	Drill
20	T2S,	R99W	S14, NW¼ NW¼	2	4f	1	51	
21	T2S,	R99W	S15, SW¼ NE¼		1		13	
25	T1S,	R99W	S27, SW¼ SE¼		2f	1	6	
28	T2S,	R99W	S11, SW¼ SW¼				1	
30	T2S,	R99W	S17, SE¼ SE¼	1f		2	20	
32	T1S,	R99W	S27, NE¼ SW¼			1f	16	
35	T2S,	R99W	S11, SW¼ NE¼				2	
36	T2S,	R99W	S11, NE¼ SE¼	1f		3f	20	Hammerstone fragment
44	T2S,	R99W	S17, SW¼ NW¼	1			1	
47	T1S,	R99W	S35, NE¼ NW¼		1f		22	
50	T2S,	R99W	S16, NE¼ NE¼				2	
52	T2S,	R99W	S15, SW¼ NE¼		1		5	
53	T2S,	R99W	S6 , SW¼ NE¼				1	Tool stone
55	T2S,	R99W	S15, SW¼ NE¼	2f			5	Mano fragment
56	T2S,	R99W	S6 , SW¼ SE¼	1				
				1f	3f			Mano, fossils
64	T2S,	R99W	S14, NW¼ SE¼	2f	3f			
65	T2S,	R99W	S14, NW¼ NW¼	1				Hammerstone
				2f		1f	110	Mano fragment
66	T2S,	R99W	S14, NE¼ NW¼	2f			35	
67	T2S,	R99W	S11, SW¼ SE¼				11	
70	T2S,	R99W	S11, SW¼ SW¼					Toolstone
71	T2S,	R99W	S11, NW¼ NW¼				9	
72	T2S,	R99W	S2 , NE¼ SW¼			1		
81	T2S,	R99W	S2 , NE¼ NE¼	1				
				2f			2	Chopper
82	T1S,	R99W	S35, SW¼ SW¼				2	Mano fragment
83	T1S,	R99W	S35, SW¼ SW¼					Mano
84	T1S,	R99W	S35, NE¼ SE¼	2f		2f	24	3 Mano fragments Hammerstone

Table 2.5.2-2 (Continued)

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
94	T1S,	R99W	S29, NW¼ SW¼		4f	2		
						1f	13	
95	T1S,	R99W	S28, SW¼ NE¼	1f			2	
97	T1S,	R99W	S30, NE¼ NW¼					Tool stone
103	T1S,	R99W	S30, SE¼ SE¼				3	
104	T1S,	R99W	S31, SE¼ NW¼				1	

* Identifiable fragmentary tool

Table 2.5.2-3 Field site number, site location and initial material culture analysis for archaeological sites located June through September 1975 on 84 Mesa, RBOSP.

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
3	T1S,	R99W	S36, NW¼ SW¼	1f*	1f		5	
17	T1S,	R98W	S18, SE¼ SW¼		1f	3f	6	
18	T1S,	R98W	S18, SE¼ SW¼	1				
				2f	1f	1f	67	
21	T1S,	R99W	S25, SE¼ NE¼	1	1f		3	Mano, Metate
22	T1S,	R98W	S18, SE¼ SW¼				9	
23	T1S,	R98W	S30, NW¼ NE¼	3	1			
				8f	2f		215	Hammerstone, drill, 3 choppers
24	T1S,	R99W	S25, NW¼ SE¼	1f			147	3 Mano fragments
26	T1S,	R98W	S20, NW¼ SW¼	1	2f	2f	1	
27	T1S,	R98W	S30, SE¼ NE¼	2f			54	Potsherds, scrapers, knives, blades
31	T1S,	R98W	S30, SE¼ NW¼	2			1	
46	T1S,	R98W	S8, SW¼ SW¼	1f			20	1 historic knife, hammerstone, 5 Mano fragments, chopper, drill
48	T1S,	R98W	S19, SW¼ NW¼	1			2	
49	T1S,	R98W	S19, NW¼ SE¼	1f			3	
57	T1S,	R98W	S19, NE¼ SE¼				74	
58	T1S,	R98W	S20, SW¼ NW¼				3	1 potsherd
59	T1S,	R98W	S20, SE¼ NW¼					Mano fragment
60	T1S,	R98W	S19, NE¼ SE¼					Mano fragment
61	T1S,	R98W	S19, NE¼ SE¼					Mano
62	T1S,	R98W	S19, SE¼ SE¼			1f	2	
63	T1S,	R98W	S20, NE¼ NW¼				2	
68	T1S,	R98W	S8, SW¼ SE¼			1f	12	
69	T1S,	R98W	S17, NE¼ NW¼				1	
73	T1S,	R98W	S18, NE¼ SE¼	1f			1	Anvil, Mano
74	T1S,	R98W	S18, NE¼ SE¼					2 Mano fragments
75	T1S,	R98W	S18, NE¼ SE¼				3	
76	T1S,	R98W	S17, NW¼ SW¼			1f		
77	T1S,	R98W	S18, NE¼ SE¼					Toolstone
80	T1S,	R99W	S13, SW¼ SE¼	1f	2f	1	30	Mano fragment
85	T1S,	R99W	S13, SW¼ SE¼		2f	5f	96	
86	T1S,	R99W	S13, NE¼ SE¼	1f	3f	1		Hammerstone fragment, 2 Mano fragments
						2f	72	

Table 2.5.2-3 (Continued)

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
87	T1S,	R98W	S30, NW¼ NE¼	1f			37	
88	T1S,	R98W	S30, NW¼ NW¼	1f		2		Mano
90	T1S,	R99W	S36, NE¼ SW¼	4f	1f	1		
						1f	20	Mano
91	T1S,	R99W	S11, SW¼ SE¼				1	
92	T1S,	R98W	S8 , SW¼ SE¼			1		
						1f*	1	
93	T1S,	R98W	S7 , NW¼ SW¼					Mano fragment
105	T1S,	R99W	S14, SE¼ SE¼		1f		1	
106	T1S,	R98W	S29, SW¼ NW¼				1	
107	T1S,	R99W	S36, SE¼		2f		14	
108	T1S,	R99W	S14, SE¼ SE¼				4	
109	T1S,	R99W	S36, NE¼ NE¼	2	2f		84	Mano
110	T1S,	R99W	S25, NE¼ SE¼			1		
111	T1S,	R98W	S30, SE¼ SW¼	1f	2f	4	102	Drill fragment, Mano fragments, toolstone
112	T1S,	R98W	S30, SW¼ SE¼				2	Toolstone
113	T1S,	R98W	S30, SW¼ SW¼	1f	1		7	
114	T1S,	R98W	S30, SE¼ SE¼				6	
115	T1S,	R98W	S30, SE¼ SE¼			1	19	Drill fragment
116	T1S,	R98W	S20, SW¼ NE¼	2	1f		13	Toolstone
117	T1S,	R98W	S29, NE¼ NW¼		2f		11	Mano fragment
118	T1S,	R98W	S7 , NE¼ NE¼	1f	2f	1f	25	2 Mano fragments
119	T1S,	R99W	S13, SW¼ NE¼				12	2 Mano fragments
120	T1S,	R99W	S11, SE¼ NE¼				2	
121	T1S,	R99W	S2 , SW¼ SE¼					Mano fragment
122	T1S,	R99W	S12, NE¼ NW¼			1f	6	
123	T1S,	R99W	S11, SW¼ NE¼		1f	1		Core, 2 Mano fragments, toolstone
						1f	21	
124	T1S,	R99W	S15, NW¼ NW¼	1			72	
125	T1S,	R98W	S19, SW¼ SE¼			1		
126	T1S,	R99W	S15, SE¼ NE¼				1	
127	T1S,	R99W	S11, SW¼ SW¼	1			2	
128	T1S,	R99W	S15, NW¼ NE¼			2f	14	3 Mano fragments, 1 hammerstone

* Identifiable fragmentary tool

Table 2.5.2-4 Field site number, site location and initial material culture analysis for archaeological sites located June through September 1975 off-tract outside Tract C-a periphery and 84 Mesa.

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
19	T2S,	R99W	S13, SW¼ NW¼	2f*	1 1f	1f	18	Mano, hammerstone
78	T1S,	R98W	S21, NW¼ NW¼	1f		1f	5	Mano fragment
79	T1S,	R98W	S16, SE¼ SW¼		1f			
89	T2S,	R100W	S13, SE¼ NE¼		1f			
96	T1S,	R98W	S9 , SE¼ SW¼					Mano fragment
98	T1S,	R98W	S5 , SE¼ SE¼				1	Mano
99	T1S,	R98W	S9 , NW¼ NW¼					Mano fragment
100	T1S,	R99W	S21, SE¼ SW¼				5	Mano fragment
101	T1S,	R99W	S21, NW¼ SE¼	1				
102	T1S,	R99W	S21, NW¼		1f			
129	T1S,	R98W	S32, NW¼ NE¼	4f	1f	1f	92	
130	T1S,	R98W	S9 , NE¼ SE¼					2 Mano fragments
131	T1S,	R98W	S9 , SE¼ SE¼					1 Mano fragment
132	T1S,	R98W	S9 , SE¼ SE¼		1f		14	
133	T1S,	R98W	S10, SW¼ SW¼					Mano fragment
134	T1S,	R98W	S9 , SE¼ SW¼				5	
135	T1S,	R98W	S21, NE¼ SW¼			1		
136	T1S,	R98W	S22, NW¼ NW¼			1		
137	T1S,	R98W	S32, NE¼ NW¼	1f				Mano fragment
138	T1S,	R98W	S31, SW¼ SW¼	1f			2	Mano fragment
139	T1S,	R98W	S10, SW¼ SE¼		1f		51	
140	T1S,	R99W	S9 , NW¼ NE¼	2f	4f	2 1f	95	Drill, 5 tool fragments, Mano, 4 Mano fragments, toolstone fragments, toolstone
141	T1S,	R99W	S9 , NW¼ NE¼	1f	1f	1	7	2 Mano fragments
142	T1S,	R99W	S10, NW¼ NW¼			1		3 potsherds, core, hammerstone, Mano, 10 Mano fragments
144	T1S,	R99W	S10, NE¼ NW¼	2f		2f	28	Mano fragment
145	T1S,	R99W	S10, NW¼ SW¼	1f	1f	3f	15	
147	T1S,	R98W	S10, SE¼ NE¼		1f	1 4f	23	
148	T1S,	R98W	S11, NW¼ NW¼	3f	2f	3f	52	
149	T2S,	R98W	S4 , SW¼ SW¼			1	3	1 potsherd

Table 2.5.2-4 (Continued)

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
150	T1S,	R98W	S32, NE¼ SE¼			2f	4	
151	T1S,	R98W	S33, SW¼ SE¼		3f	1	4	Mano fragment
152	T1S,	R98W	S11, NW¼ SE¼	1	1f	1	12	Mano, hammerstone, 1 hammerstone fragment
153	T1S,	R98W	S11, NE¼ NE¼	1f	4f	7	118	Mano fragment
154	T1S,	R98W	S2 , SW¼ SW¼	1		1		
				2f*	1f	2f	8	Mano
155	T1S,	R98W	S2 , SW¼ SW¼				5	
156	T1S,	R98W	S2 , SW¼ SW¼				4	
157	T1S,	R98W	S2 , NE¼ SW¼				21	
158	T1S,	R98W	S11, NW¼ NW¼				5	
159	T1S,	R98W	S11, NW¼ NW¼			4	9	Hammerstone, 3 Mano fragments
160	T1S,	R98W	S16, NE¼ NE¼	1f	4f	4f	42	1 potsherd, 1 Mano, 3 Mano fragments
161	T1S,	R98W	S16, SW¼ NE¼		1f		4	
162	T1S,	R98W	S34, NW¼					Mano fragment
163	T1S,	R98W	S33, NE¼ NE¼				4	Mano fragment
164	T1S,	R99W	S8 , NE¼ NE¼	2f	4f		10	Hammerstone, 6 Mano fragments
165	T1S,	R98W	S16, SE¼ SE¼	2f	1f		5	Core
166	T1S,	R98W	S1 , SW¼ NW¼		1	1	9	Mano, Mano fragment
167	T1S,	R98W	S35, SW¼ SW¼	2f	1f		2	2 cores, Mano fragment
168	T2S,	R98W	S2 , SE¼ SE¼				3	
169	T1S,	R97W	S19, SW¼ SW¼				2	Mano fragment
170	T1S,	R97W	S18, SE¼ NW¼				1	
171	T1S,	R98W	S29, NE¼ NE¼				3	
172	T1S,	R98W	S28, NW¼ NW¼				3	
173	T2S,	R98W	S6 , NW¼ NW¼			3	5	
174	T1S,	R98W	S31, NW¼ NE¼		1f	2f	10	Mano, Mano fragment
175	T1S,	R98W	S31, NW¼ NE¼		1f	2f	10	Mano, Mano fragment, 5 tool fragments
176	T1S,	R98W	S31, NE¼ NE¼			1	7	Mano, tool fragment, core
177	T1S,	R98W	S32, NW¼ NW¼					Structures

Table 2.5.2-4 (Continued)

Field Number	Township	Range	Section	Point	Knife	Scraper	Flakes	Other
178	T2S,	R98W	S6 , NE¼ NE¼	1f		1		
179	T1S,	R98W	S32, SW¼	1f			3	Tool fragment
180	T1S,	R98W	S31, SE¼	1f			2	Tool fragment
181	T1S,	R98W	S32, SW¼ NE¼		1f		11	Tool fragment
182	T1S,	R98W	S31, SE¼ SE¼				38	Tool fragment
183	T2S,	R99W	S14, NE¼ SW¼					Tool fragment
184	T2S,	R99W	S23, NE¼ SW¼				1	Tool fragment
185	T2S,	R98W	S19, NW¼ SW¼			1	1	Tool fragment
186	T1S,	R98W	S1 , SW¼ NE¼	2f*	1f	3f	36	Hammerstone, Mano fragment, 4 tool fragments
187	T1S,	R98W	S36, SE¼				1	Hammerstone, Mano
188	T1N,	R98W	S25, NE¼	1f		1	10	Mano, Mano fragment, 5 tool fragments
189	T2S,	R98W	S3 , NW¼	1f	1f	1	45	2 tool fragments
190	T2S,	R98W	S4 , SE¼ NE¼		1f	5	41	3 Mano fragments, 3 tool fragments
191	T2S,	R98W	S4 , NW¼ NE¼	1				
				1f			8	Mano, 2 Mano fragments, 2 tool fragments
192	T1N,	R98W	S23, NW¼ NW¼			1	1	
193	T1N,	R98W	S23, NE¼ NW¼	1f		1	14	Tool fragment, Mano fragment
194	T1N,	R98W	S13, W½	3f		2	3	3 tool fragments, 2 hammerstone fragments, 3 tool fragments
195	T1S,	R98W	S34, NE¼ SE¼	1				
196	T1N,	R98W	S31, NW¼ NE¼		1			
					1f	2f	10	Mano, Mano fragment, 3 tool fragments

* Identifiable fragmentary tool

although most meadow species are not commonly used for food. Agriculture was probably not practiced in the Basin, although it may have been in lowland areas to the north and east along the major drainages.

Hunting was a primary concern, but the killing and butchering of deer or elk leaves very little evidence. Once the meat has been stripped from the bones, or the animal butchered, the meat utilized and the bones discarded, the evidence disappears through natural processes. Soil formation and the covering of the bones by alluvial action did not seem to occur. No kill sites were found.

Field analysis indicates there were at least four periods of occupation of the area: an Archaic period followed by the Fremont culture, then Ute and finally Anglo.

The Archaic or Desert Culture was initially defined in Utah. Similar material has been found in the high valleys and drainages on the Western Slope of Colorado. Similar tools have been found in southern Wyoming and along the Front Range of Colorado. The time depth in Utah can be extended back at least 10,000 years.

The social unit seems to have been a family of two or perhaps three generations including husbands and wives and dependent children. Seasonal opportunities dictated the movement of the group and any resource that produced edible food was exploited. A considerable knowledge of natural history, seasonal patterns of game movements and ripening times of various plants was needed. Material culture was geared to frequent changes in location. Flexible containers of hide or basketry were used instead of ceramics. Other types of equipment were practical and portable. Clothing was minimal and housing only constructed when a subsistence item was plentiful enough to support the group in one place for a period of time. Caves or overhangs were used when they occurred. Exploitation patterns indicate that, in addition to game and plants, fish, insects, waterfowl, rodents and reptiles were eaten. Artifacts from this sample that can be identified with the Archaic are primarily projectile points. Dating of this occupation could extend back several thousand years, but this inference cannot be positively confirmed from surface material.

The Fremont Culture, originally defined from Utah and northwestern Colorado, continues the Archaic pattern of subsistence. Agriculture and pottery were diffused into the area from the Southwest. Prior to A.D. 400, there was considerable influence from the Four Corners region. Five subdivision of that pattern have been identified in Utah and two border the northwestern portion of Colorado. One, the Uinta area, is located in northeastern Utah and the San Rafael, the other, is in eastern central Utah. The time span for these periods is from approximately A.D. 450 to 1400. These groups revealed less puebloan contact.

Most artifact material shows a continuation from the Archaic. Projectile points decreased in size and differed in outline, but most tools were not altered. Ornaments and pottery were added and leather footgear and clothing become more common. Clay figurines of men and women have been found in several areas, but not in the Tract C-a area. While agriculture expanded the economic base, hunting and gathering were still most important. Social patterning did not differ significantly from that of the Archaic.

The Meeker region is noted for the Ute massacre at Meeker's trading post. The time and extent of the Ute occupation is less well known. The Ute may well be a continuation out of Fremont, with the addition of the horse and items of European manufacture. Several sites were found which had Wickiups or the conical frames for small houses. The shape is tipi-like, with the use of smaller brush and juniper bark as the covering. Some are still standing and show the interlocked main frame elements. Unfortunately, artifacts at these sites were very scarce and do not aid in dating the structures. At one site, a butcher knife was found; however, this could have been lost by Anglos.

Recent historic material is largely that left by deer hunters. Several early ranches, houses and a school are near the study area. There is a historic horse trap on 84 Mesa that has not been in use for some time. The majority of Anglo occupation is in the Ryan Gulch and Yellow Creek areas.

2.5.3 Revegetation

2.5.3.1 Objectives

The extraction and processing of oil shale rock from Tract C-a will result in the creation of processed oil shale disposal piles. As an integral part of the rehabilitation plans for lands affected by oil shale processing, these disposal piles are to be reclaimed in such a way as to be compatible with the existing landscape and the biota which inhabit it. Revegetation methods should be available at the onset of shale processing to assure that this compatibility is realized.

The overall goal of a revegetation plan for Tract C-a disposal piles is to develop self-sustaining plant (and animal) communities in equilibrium with local climate and substrate conditions, and not wholly unlike the existing vegetation. Although considerable research has been done on methods of revegetating semi-arid lands and processed oil shale, it is not specific enough to meet the objectives set forth above for revegetation of Tract C-a disposal piles. Thus, a series of long-term experiments to fill existing data voids are to be conducted. The initial revegetation program is designed to run from Fall 1975 through Winter 1978. It will involve the application of a number of treatments, such as mulching types, fertilizer schedules, and a species combination to a number of artificially created substrates in field test plots designed to simulate, to some extent, processed shale disposal piles. Based on the results of these studies, additional experiments will be determined in conjunction with the Area Oil Shale Supervisor.

The characteristics of processed oil shale disposal piles, as envisioned at this time, are pertinent to the revegetation program. The design elements of these disposal piles are being developed jointly by engineers and ecologists in an attempt to create substrates which are conducive to successful revegetation. Tract C-a revegetation experiments are discussed in light of the planned disposal pile characteristics and in light of existing knowledge about revegetation of the area and substrates incorporating processed oil shale.

2.5.3.2 Methods

a. Design of Disposal Piles - As a basis for designing initial revegetation experiments, it was necessary to consider the characteristics of processed oil shale piles to be revegetated and the kinds of information available on revegetation techniques for semi-arid lands and spent oil shale substrates in particular.

Preliminary designs call for a typical disposal pile to have the following strata, from top to bottom;

10 to 15 cm (4 to 6 inches) of topsoil
15 to 30 cm (6 to 12 inches) of topsoil
30 to 60 cm (6 inches) of crushed rock
60 to 100 cm (2 to 3 feet) of large boulders
150 cm (5 feet) of 95% compacted processed oil shale

0 to several hundred meters (0 to several hundred feet) of 80% compacted processed oil shale
150 cm (5 feet) of 95% compacted processed oil shale
(The above values represent minimum depths for each strata.)

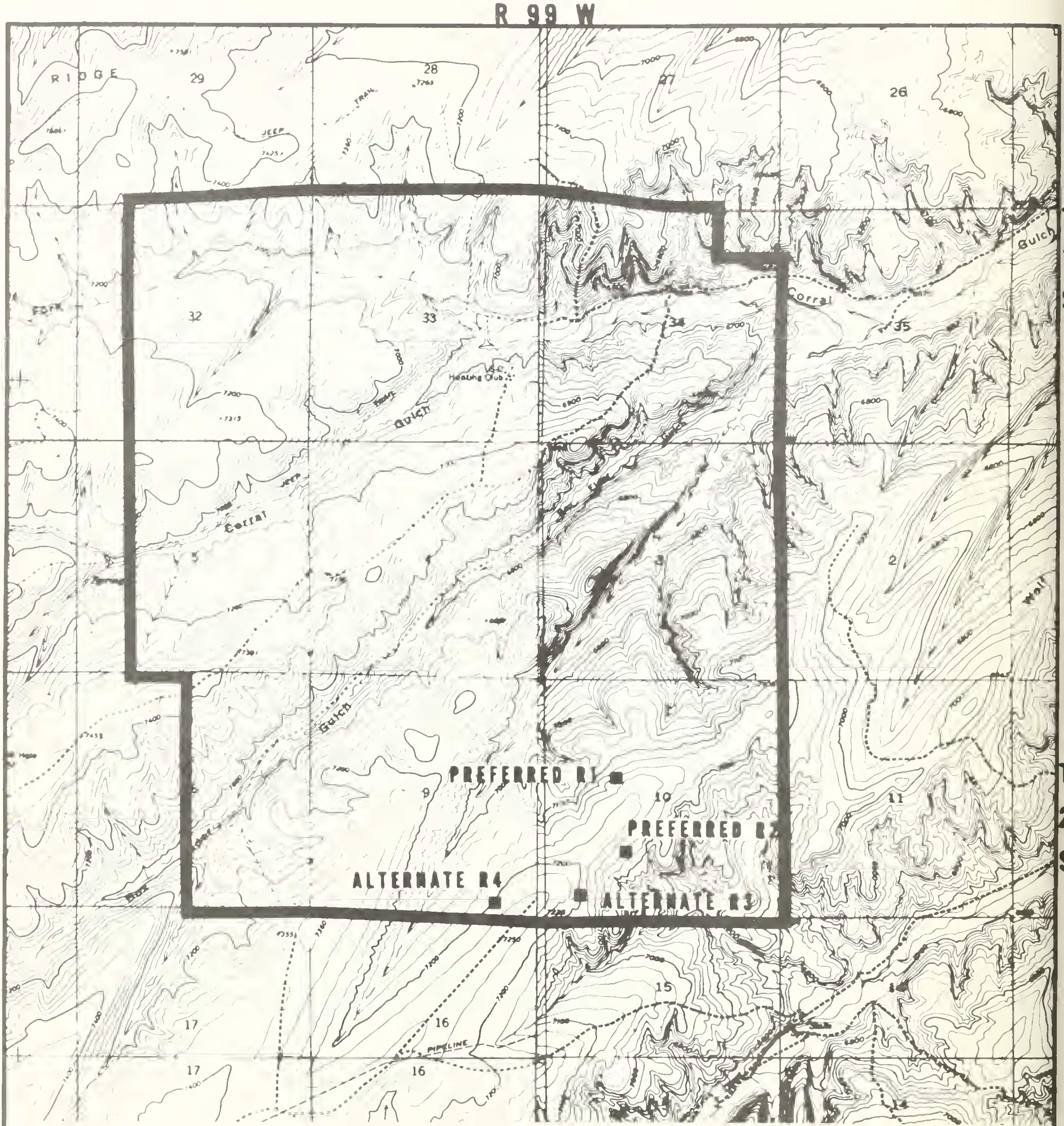
Sopes will be recontoured to blend with the natural landscape, with slopes of not more than 33% (3:1) where revegetation is planned. Catchment basins will be constructed to collect excess runoff. Topsoil substrate and crushed rock will probably be obtained from the same location as the disposal piles.

The configuration and internal characteristics of disposal piles as described above should provide an adequate rooting medium to support plant cover comparable to pre-mining conditions. Topsoils will assure reasonable levels of organic matter and nutrients and provide a residual seed and rhizome source while subsoils should retain moisture for utilization during periods when evaporation normally exceed precipitation. The overburden and/or quarried rock layers are designed to: 1) reduce mass movement of soils, 2) break capillary migration of dissolved salts from the processed oil shale up into the active rooting zone where excess salts could inhibit plant growth, and 3) inhibit contact of roots with spent oil shale where toxic elements may be incorporated into plant tissues and subsequently ingested by herbivores.

Although the precise location of disposal piles resulting from Tract C-a mining has not been determined, preliminary plans suggest that they will be situated in the 84 Mesa area (T1S, R99W, Section 23 and 24), to the northeast of the tract. Soils on the proposed offsite disposal area are similar to those found on the revegetation site (SCS, 1975). The vegetation is predominantly sagebrush and pinyon-juniper.

b. Selection of Species - A mixture of species which will provide a greater stability and a greater diversity of food and cover for local fauna will be used.

c. Location of Test Sites - Location of preferred and alternate test sites are presented in Figure 2.5.3-1. All sites are situated on side slopes between elevations of 2160 and 2200 m (7100 and 7200 feet) adjacent to Wolf Ridge Road in the southeast corner of the tract (T1S, R99W, Section 10).



LEGEND

▬ TRACT OUTLINE

■ 1975 REVEGETATION TEST PLOTS

GULF - STANDARD (INDIANA)

RIO BLANCO OIL SHALE PROJECT

TRACT C-a

RIO BLANCO COUNTY, COLORADO

Figure 2.5.3-1

0 3000

The first year experiments will utilize two sites on opposing slopes at comparable elevations and steepness to test for the effect of aspect on revegetation success. Trials in the two subsequent years will utilize a single site on the slope having the more extreme drought conditions of the two original sites tested.

d. Plot Layout - Sixteen treatments will be applied to a 10 by 10 m (3.28 by 3.28 feet) plot and replicated three times at each site. Each plot will be surrounded by a 3-m (9.84 feet) buffer zone. Treatments will be allocated randomly in each of three complete blocks located adjacent to each other. The total dimensions of a site sample area will be 55 by 165 m (180.4 by 541.2 feet) or 9,075 m^2 (0.91 ha/2.24 acre).

Within each 10 by 10 m treatment plot a minimum of three 1 by .5 m (3.28 by 1.64 feet) subplots will be randomly established and marked permanently for subsequent data collection.

Test sites will be fenced with four-strand barbed wire to discourage large grazers, primarily wild horses and cows. Raptor perches will be constructed along the periphery of test sites to discourage concentration of small grazers.

e. Seedbed Preparation - Native vegetation will be scraped from the two experimental plot sites prior to substrate mixing and transported to adjacent areas for brush piling. Topsoil [about the upper 15 cm (6 inches) of the soil] and remaining subsoil will be stockpiled separately. The underlying bedrock, consisting of fractured calcareous sandstone will be removed for a minimum thickness of 46 cm (18 inches), broken up and spread back over the area to simulate overburden. Subsoil and topsoil will then be replaced and graded for sowing. Final grade will approach 3:1.

As part of the site preparation process, an appropriate perimeter will be disturbed around each site, thus bringing the total area of disturbance per site to 1.7 ha (4.3 acres). Materials (topsoil, subsoil, overburden) which are to be stockpiled temporarily (10 days maximum) will be located in the disturbed perimeter.

f. Sowing Methods - All seed will be drilled into the ground prior to mulching using a conventional grassland drill equipped with a single seed box and agitator. Drilling is preferred to broadcast seeding because less seed is required and greater moisture surrounds the seed during the critical stages of germination. Drilling will result in a spacing of 13 to 18 cm (5 to 7 inches) between planting rows.

g. Species and Sowing Rates - A composite mixture of grasses, forbs and woody plants (Table 2.5.3-1) will be sown in preference to pure species stands. This mixture will consist of both introduced and native species. The introduced species, especially the wheatgrasses, are quite aggressive and are thus suited to rapid establishment and stabilization of the substrate. In contrast, the less aggressive native species are generally more successful in later stages of plant community development. The suitability of each species as wildlife food and cover, as soil stabilizers and as resistors of drought is presented in Table 2.5.3-1.

For purposes of the 1975 test, approximately 18 kg/ha (16 lbs/acre) of seed will be sown, with grasses and non-grasses (forbs and woody plants) in equal 9 kg (8.1 pound) proportions (Table 2.5.3-1).

h. Treatments - For the 1975 test, a total of 16 treatments will be applied using all possible combinations of the following variables:

- Mulch Type and Application (applied to cover approximately 70% of the soil surface)

    1. No mulch
    2. Hydromulch with wood fiber
    3. Straw mulch followed by crimping
    4. Straw mulch with neeting

- Fertilizer Application (10-5-5 applied at a rate of 180 kg/ha (160 lbs/acre)

    1. No fertilizer
    2. Fertilizer at time of sowing (fall)
    3. Fertilizer at beginning of first full growing season
    4. Fertilizer at time of sowing and at beginning of first full growing season

Table 2.5.3-1 Plant species suitability and recommended sowing rates kg/ha, lbs/acre of viable seed for species utilized in revegetation experiments on oil shale Tract C-a, Rio Blanco County, Colorado

Species	Suitability Rating[a]	1975 and 1976 Seeding Rates	
GRASSES		kg/ha	lbs/acre
Luna pubescent wheatgrass (*Agropyron trichophorum* var. *luna*)	2,4,6,8,9	1.7	1.5
Rosana western wheatgrass (*Agropyron smithii* var. *Rosana*)	4,5,8,9	1.7	1.5
Sodar streambank wheatgrass (*Agropyron riparium* var. *Sodar*)	3,5,8,9	1.7	1.5
Indian ricegrass (*Oryzopsis hymenoides*)	2,4,5,7,9	0.7	0.6
C-43 basin wild rye (*Elymus cinereus* var. *C-43*)	2,4,5,7,11	1.7	1.5
Green needlegrass (*Stipa viridula*)	2,5,7	1.7	1.5
FORBS			
Lewis flax (*Linum lewisii*)	2,5	0.6	0.5
Lutana cicer milkvetch (*Astragalus cicer* var. *Lutana*)	6,11	0.6	0.5
Utah sweetvetch (*Hedysarum utahensis*)	2,5	0.6	0.5
Madrid yellow sweetclover (*Melilotus officinalis* var. *Madrid*)	2,4,5,9,11	0.6	0.5
Rocky Mountain penstemon (*Penstemon strictus* var. *bandera*)	3,5,9	0.6	0.5
Scarlet globemallow (*Sphaeralcea coccinea*)	3,5,9	0.6	0.5
SHRUBS			
Big sagebrush (*Artemisia tridentata*)	2,5,9,10,11	0.2	0.2
Little rabbitbrush (*Chrysothamnus viscidiflorus*)	2,4,5,9,11	0.2	0.2
Bitterbrush (*Purshia tridentata*)	1,5,9,10,11	1.1	1.0
Mountain mahogany (*Cercocarpus montanus*)	1,5,10	0.6	0.5
Fourwing saltbush (*Atriplex canescens*)	1(seeds), 3, 4,5,9	1.1	1.0

Table 2.5.3-1 (Continued)

Species	Suitability Rating[a]	1975 and 1976 Seeding Rates	
SHRUBS (Continued)		kg/ha	lbs/acre
Winterfat (Eurotia lanata)	1,5,10	0.6	0.5
Rubber rabbitbrush (Chrysothamnus nauseosus)	3,5,9,10,11	0.6	0.5
Snowberry (Symphoricarpos oreophilus)	2,4,5,10	0.6	0.5
Squaw bush (Rhus trilobata)	2,4,5,9,10,11	0.6	0.5
TREES			
Utah juniper (Juniperus osteosperma)	3,5,9,10,11	0.1	0.1
Pinyon pine (Pinus edulis)	3,5,9,11	0.1	0.1

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[a] Suitability ratings are:

1. Highly palatable
2. Moderately palatable
3. Unpalatable
4. Soil stabilizer
5. Native to Colorado[b]
6. Introduced species
7. Bunch grass
8. Sod grass
9. Drought resistant
10. Browse
11. Cover for game

[b] Underlining indicates species observed on site as part of the environmental baseline studies (Limnetics, Inc., June 1975).

i. Plant Response Parameters - The following plant response parameters will be measured for each treatment:

1. Number of emerged seedlings per plot,
2. Number of surviving seedlings per plot,
3. Above-ground biomass,
4. Percent cover, and
5. Vigor

Table 2.5.3-2 gives the season of measurement for each parameter and the taxa involved, Photographs will be taken from fixed points in at least one replicate of each treatment at the times of data collection. A qualitative measure of alien species success will be obtained from in-situ counts of germination in buffer areas and from germination rates in soil samples collected from buffer areas and placed in the greenhouse.

j. Statistical Analysis - For the dependent variables of number of emerged seedlings, number of surviving seedlings and biomass at a particular site and in a particular year, the following analysis of variance is given:

Source of Variation	Degrees of Freedom	
Block	2	
Treatment	15	
Mulch		3
Fertilizer		3
Mulch x Fertilizer		9
Error A	30	
Species	22	
Treatment x Species	330	
Species x Mulch		66
Species x Fertilizer		66
Species x Fertilizer x Mulch		9[illegible]
Error B	704	
Total	1103	

k. Environmental Data - Soils and climatic data will be collected periodically during the study period in order to attempt to establish more closely the causal links between plant response to varying treatments and the soil and climatic factors eliciting these responses. Soil moisture will be measured using standard gravimetric techniques from

Table 2.5.3-2 Plant response parameters measured in initial revegetation studies on oil shale Tract C-a, Rio Blanco County, Colorado, 1976-1978

Parameter	Time of Measurement	Taxa Involved
Number of emerged seedlings per plot	first spring following fall planting, i.e., beginning of first growing season	each planted species
Number of surviving seedlings per plot	end of first growing season	each planted species
Above-ground biomass (dry wt.)	end of third growing season	total seeded species, total alien species, individual seeded species contributing bulk of biomass
Percent cover	end of third growing season	each species
Vigor	end of first, second, and third growing seasons	each planted species

soil samples collected at 15 cm intervals throughout the soil column. Soil moisture determinations will be made periodically on three samples at each site during the growing season.

Soil samples will be collected at each site and pH, exchangeable sodium percentage, available nitrogen, phosphorus, and potassium, electrical conductivity, percent organic matter and concentrations of zinc and molybdenum will be determined with standard laboratory techniques.

Two samples will be collected at each site during each growing season at 15 cm (6 inch) intervals.

1. Revegetation Trials in Years 2 and 3 - Revegetation experiments initiated in Year 2 (Fall 1976) and Year 3 (Fall 1977) will essentially duplicate those initiated in Year 1, except that a layer of Paraho processed oil shale approximately 15 cm (6 inches) in thickness will be placed over the bedrock and below the simulated overburden. Comparison with Year 1 experiments should provide some insights into the effect of processed oil shale in revegetative success, particularly with regard to the influence of salt and heavy metals.

   Trials 2 and 3 will be conducted on one site (as opposed to two in Trial 1) and will be monitored for a minimum of 3 years as is the case with Trial 1.

   Additional experiments will be determined in conjunction with the Area Oil Shale Supervisor. They will depend in large on results obtained during the initial revegetation program and on the availability of actual processed oil shale.

2.5.4 Toxicology

No changes have occurred since Progress Report 3. Refer to RBOSP Progress Report 2 for specifics on methodology.

2.5.5 Trace Metals

Soil samples from two SCS pits have been collected and submitted for analyses, the results of which have not as yet been received. Other trace metal studies are being included in a proposed soil sampling program that will be described in RBOSP Progress Report 5.

2.5.6 Visibility Studies

A joint venture visibility study is currently in the contractual stage. It is anticipated that RBOSp Progress Report 5 will present a detailed description of the study.

2.5.7 Seismicity

The results of the seismicity study was presented in RBOSP Progress Report 3. No additional work is contemplated.

Appendix A

APPENDIX A

A 1.0 Introduction

In the appendix sections of Progress Reports 2 and 3 - Summaries, the engineering studies being done by Morrison-Knudsen and Foster Wheeler were described. Also presented was the status of the offsites work being performed by RBOSP and its contractors. These studies are providing the information for the Detailed Development Plan and for making estimates of capital and operating costs which will aid in predicting the economic viability of the project. This appendix section will update the engineering and offsite work in progress. Also is a Gantt and milestone chart which includes schedules for installation of offsite facilities, construction and development of mining and processing facilities, and operational schedules (Figure A-1). The relative location of the major offsite facilities discussed are shown in figure A-2.

A 2.0 Engineering Studies

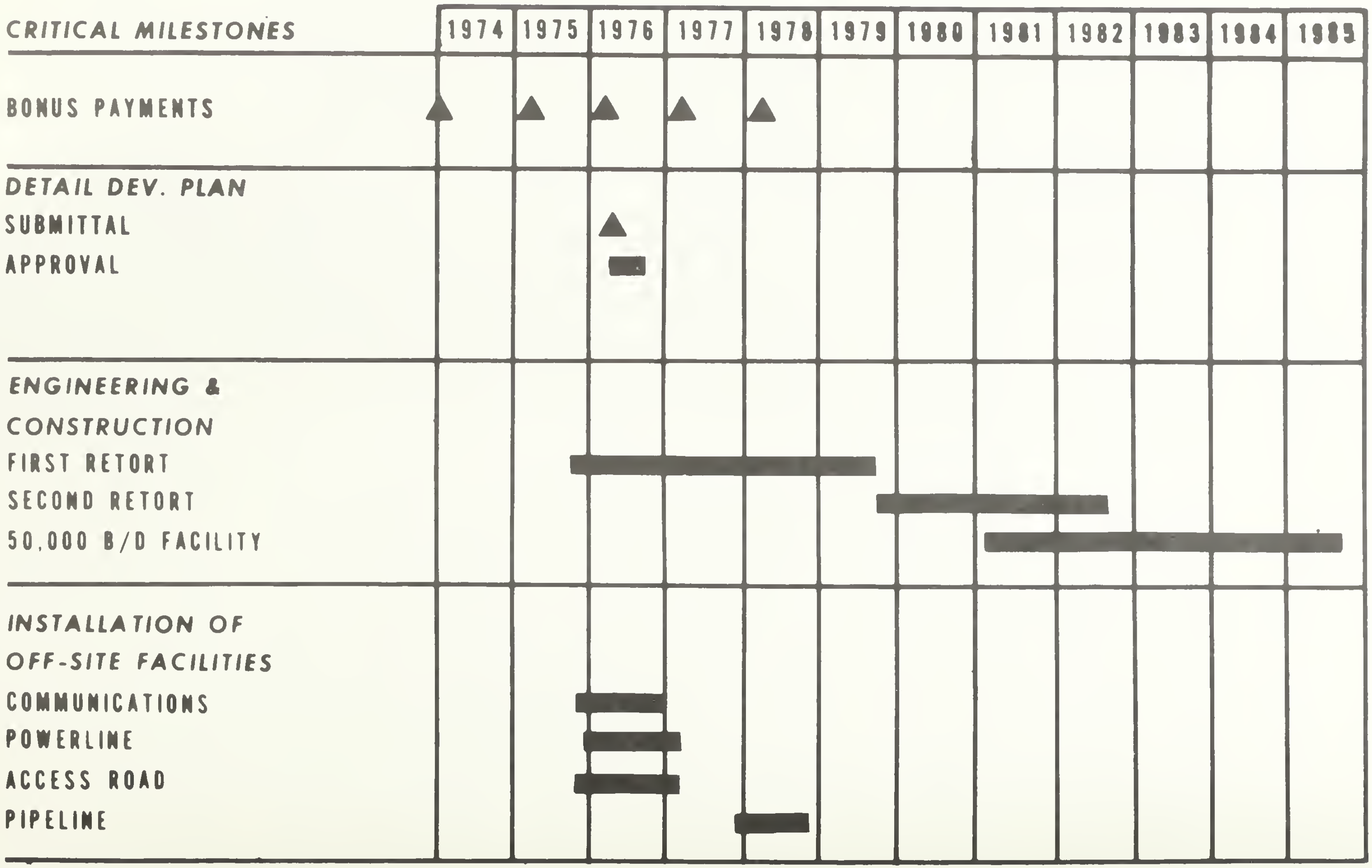
The engineering work is proceeding as outlined in earlier Progress Reports. RBOSP is still planning a modular approach to arrive at full development -- starting with one TOSCO II retort. Both underground room & pillar and open pit mining methods for supplying ore to the first retort are still being studied. For ultimate development the open pit mine is favored largely because approximately five times more oil shale reserve can be recovered than by underground mining.

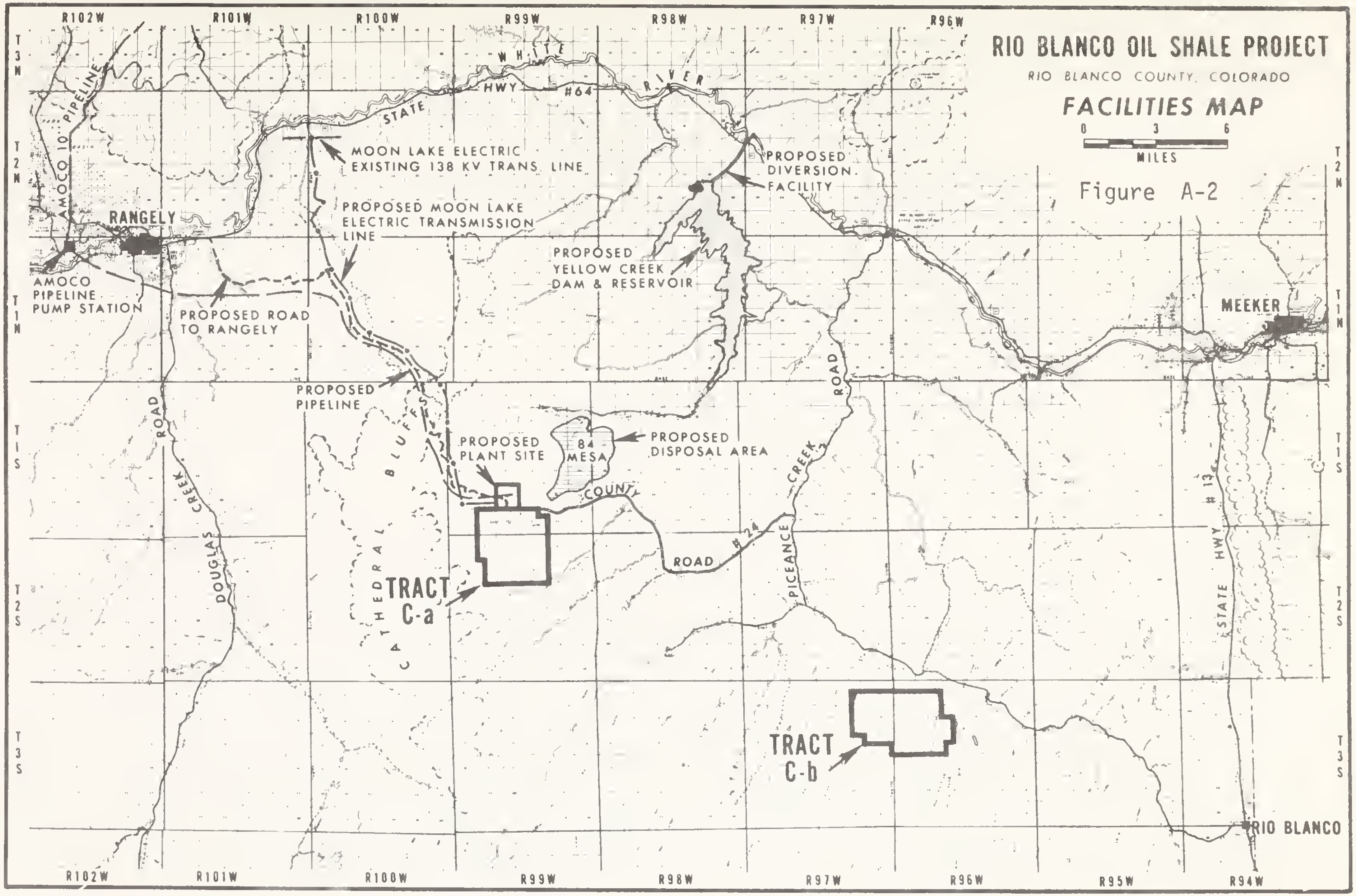
In addition to the DDP and economic studies, work is now far enough along that final design work of the first processing module has started. RBOSP expects to continue this work without interruption beyond the end of this year when the present engineering contract ends.

Now that engineering work is further along, estimates of a realistic schedule can also be developed. The schedules are shown in Figure A-1. The key to the schedule is the Detailed Development Plan and its approval. RBOSP plans to submit it to the Area Oil Shale Supervisor by the end of March, 1976. For scheduling purposes, it was assumed that approval will take six months, and that by October 1, 1976, RBOSP will have full permission to proceed from the Area Oil Shale Supervisor, and also from the parent companies, Gulf Oil Corporation and Standard Oil Company of Indiana.

The modular approach envisions starting with one TOSCO II retort to produce about 7000 B/D of pipelineable oil. Engineering for this first module has already started as mentioned earlier. RBOSP is pacing this engineering work so that it will be ready to place orders for long delivery items by October, 1976, when permission to proceed is received.

Figure A-1. Schedule and Milestone Chart - RBOSP





RIO BLANCO OIL SHALE PROJECT
RIO BLANCO COUNTY, COLORADO
FACILITIES MAP

Figure A-2

Site preparation on the tract is scheduled to start in April, 1977, and will require about 3 months. This will be followed by the start of actual field construction. The peak field force for this construction will be about 800 men. The mine is scheduled to be in operation in July 1979, one month before the processing facility is ready to start up. Approximately 370 people are required for the mine and plant operation.

Engineering for the second module will start in August, 1979 and will be completed three years later in August, 1982. About 400 construction people will be required for the second module.

Engineering for the nominal 50,000 BPD facility starts in February, 1981, and continues for 18 months before field construction starts. For this bigger facility 3 years are required in the field and completion is scheduled for August, 1985. The construction force will be about 2200 people and the permanent operating force will be about 1150 people.

A 3.0 Offsite Facilities

In order to start construction of the first retort by April 1, 1977, the telephone system, access road and power line must all start construction during the 1976 construction season. As shown in figure A-1, the telephone system installation must start April 1, 1976, the access road construction will follow a month later on May 1st, 1976, and the electric power line construction must start by September 1, 1976. The only offsite facility not needed prior to construction of the plant is the product pipeline which can be constructed during the summer season of 1978. Not shown is the schedule for the Yellow Creek water reservoir and water supply pipeline. These probably won't be needed until expansion of capacity above 50,000 barrels per day occurs.

Since RBOSP does not expect approval of the Detailed Development Plan until Ocotber 1, 1976, it had to work out a way that the off-site facilities construction could be started prior to approval of the Detailed Development Plan. This has been done by agreeing with the Bureau of Land Management on the routes for these facilities, followed by environmental assessment teams being assigned by the BLM to evaluate the routes in detail and provide for minor deviations to be incorporated as the work progresses in order to mitigate the environmental impact as much as possible. This work is currently underway with a 10-man team assigned to a combined corridor which includes the access road to Rangely, the electric power line and the product pipeline. Evaluation of the telephone installation is comparatively minor since Mountain Bell plans to follow the Piceance Creek Highway from the Rio Blanco store, then alongside the Ryan Gulch County Road #24. This installation will be an underground cable connection to the telephone exchange in Meeker.

In order to start construction of these offsite facilities in early 1976, it is necessary to do the engineering and design work in late 1975. In the case of the telephone system, which will be installed by Mountain Bell, engineering work is already proceeding, although the final agreement with Mountain Bell has not yet been signed. The telephone system will cost in excess of $500,000.

RBOSP estimate that it will take two contractors about 10 months to construct some 22 miles of new road to connect the plant site to Rangely. At the same time, it would be necessary to improve about 14 miles of County Road #24, including relocation of about 6 miles to connect with the plant site at the upper end and allow access to Meeker. A Letter of Intent has been sent to the Bureau of Land Management requesting use of Section 28, immediately north of Tract C-a, as a plant site. RBOSP has also sent a Letter of Intent to the Bureau of Land Management requesting 84 Mesa for a solids waste disposal area. The BLM does not believe it has the authority to grant either the proposed plant site or the solids waste disposal site. Therefore, the Interior Department recently has introduced legislation to the current Congress which would grant BLM the needed authority. RBOSP's plans for open pit mining of Tract C-a are based on the assumption that it will eventually be granted use, for appropriate payment, of these off-tract lands. Without these, open pit mining of C-a makes little sense.

Based on a preliminary plot plan for the processing facilities, RBOSP has selected the route for the road to pass to the north of Tract C-a, then cross Corral Gulch about a mile east of C-a and proceed along a relocated route on the south side of Corral Gulch to connect with existing County Road #24 just below the old 84 Ranch buildings. Thus, plans call for an access road to either Rangely or Meeker and other points to the east. This leaves the choice of communities to live in up to each employee. Also, the road length from Rangely to Rifle would be shortened about 7 miles.

RBOSP has been working closely with the Rio Blanco County officials and the State Highway Department with regard to design and location of this road. It is hoped that Rio Blanco County will submit a formal application for the right-of-way together with the centerline survey before the end of November 1975. This will allow RBOSP to proceed at full speed with the detailed engineering design of the highway. The design work will require about 6 months to complete, and this should be followed by about one month for review of the design by the Colorado Department of Highways, and another month to advertise and award the construction contracts in order to meet the very tight schedule. RBOSP will arrange for the detailed engineering design of the highway, and it is hopeful that Rio Blanco County can receive oil shale bonus money from the State for design and construction of the highway. It is estimated that the Rangely access road will cost about $10.2 million when completed and paved. RBOSP estimates costs of about $2.2 million for relocating and paving the Meeker access.

An agreement with Moon Lake Electric Company was signed in September, 1974, for installation of a 230 KV transmission line from a point on their existing line just south of Highway 64 to a substation in the proposed plant area in Section 28, a distance of about 20 miles. At this time, all of the major materials required for the line such as poles, wire and insulators are on order. Moon Lake expects delivery of the materials in the period from March to June, 1976, so RBOSP expects construction to commence as scheduled and require about 6 months for completion. The line and 10 megawatt substation required during the plant construction phase will cost around $1,200,000. The substation will have to be enlarged to about 50 megawatts capacity for the first modular retort and later raised to about 200 megawatt capacity when the plant is expanded to 50,000 barrels per day.

The shale oil pipeline, as stated previously, will not be installed until 1978. However, RBOSP recently contracted with the Gulf Refining Company for the design of the pipeline together with preparation of the description of the pipeline and its safety features, which is required for the Detailed Development Plan.

The routing for the pipeline will run from the existing Amoco Rangely station in a southeasterly direction, paralleling existing pipeline rights-of-way, until it crosses the Douglas Creek Highway, and nears Gillam Draw. From that point, the pipeline route will run easterly to merge with the access road corridor, and will then stay within the road-transmission line general corridor on to Tract C-a. After the detailed centerline routings of the road and transmission line are finalized, the routing of the pipeline will be initiated in detail.

The pipeline will be of steel welded construction, be buried with a minimum cover of 3 feet, have all safety devices and comply with Federal Department of Transportation stipulations regarding design, operating, and maintenance criteria.

A 4.0 Water Acquisition Program

RBOSP's program is to acquire a net of 60,000 acre-feet of water per year, which is needed for the ultimate potential development. The requirements will be made up from the development of both surface water and groundwater to optimum capacity. Work is proceeding for both the surface water and groundwater systems. Applications are pending in the Water Court in Glenwood Springs, through which RBOSP hopes to achieve the necessary court approval for our plans. The request for change in point of diversion of the Rocky Mountain Power Company industrial water rights on the White River has been scheduled for a pre-trail on February 2nd, 1976. A pre-trail hearing on the groundwater application was held on September 22nd, 1975 and the trial time has been set for January 12th, 1976. At the pre-trail, RBOSP withdrew the reserved rights claim because it had received a statement from the Solicitor of the U. S. Department of Interior that they would not support it.

RBOSP is in the midst of preparing exhibits for the groundwater court trial, based on the hydrology baseline data gathered so far, together with interpretations by a computer model of the Piceance Basin. Alternative plans of augmentation which will protect existing users on those streams that we may impact are also being prepared. The exhibits and plans will be reviewed with both the State Engineer and the USGS Department of Water Resources prior to the trial date, so that they will be familiar with the exhibits and the investigations behind the conclusions that have been reached.

A 5.0 Miscellaneous

RBOSP recently reached an agreement with Marathon Oil Company to mine about 100 tons of Mahogany zone shale from Marathon's mining claims located about 1.4 miles northwest of Tract C-a. This bulk sample is assumed to be representative of the ore which will be mined from Tract C-a in the future. This shale has already been processed through the TOSCO pilot plant near Golden, Colorado, and numerous samples of oil, gas and spent shale have been obtained. The analyses of these samples will be utilized to obtain process design information, and for conducting an extensive two-year toxicology program which includes exposure of laboratory animals to various fractions of the shale oil product and to raw and spent shale dust.

Form 1279–3
(June 1984)

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